BLOOD CHANGES IN THE PARTURIENT BOVINE.

by

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A. GENERAL INTRODUCTION.

The history of milk fever goes back about one hundred and fifty years and the disease is thought to have originated at the time when the modern heavy milking strains of cow were being developed (55). Through the years that followed, some thirty theories as to the cause of the condition have been put forward (53), but the first major advance was made by Schmidt (76), who thought he saw signs of infection in the milk of a cow with parturient paresis. Accordingly, he injected the udder with a solution of Potassium Iodide, which he believed to be antiseptic, and found a high percentage of recoveries taking place. The treatment gradually became modified to an injection of water; later oxygen was used and finally air (5, 58), all with beneficial results. There was never any really satisfactory explanation at this time as to how udder inflation acted and little advance was made until 1925.

In that year, Dryerre and Greig published a preliminary article (23), without any experimental evidence, pointing out the similarity of the symptoms of milk fever to those of parathyroidectomised dogs. In this paper they

of milk fever. Consequently, they undertook the analysis of blood from such cases and were eventually able to confirm their hypothesis (24, 40, 41). They were not the first to publish experimental evidence of a hypocalcaemia, however, as Little and Wright (61) put forward evidence of this only two months after Dryerre and Greig's original article.

At about the same time, the theory was advanced that milk fever was a hypoglycaemia (64, 93), but this was soon criticised by other workers who considered that a high blood sugar level existed (27, 45, 49). The matter was finally cleared up by Hayden (45, 49) and Fish (27, 28), who showed that, after udder inflation, the increase in blood sugar was due to lactose, which is not utilised by the tissues, and is rapidly excreted. Another theory was advanced by Moussu (67) in 1928 that milk fever is a hypocholesterinaemia. In the following year, however, Hayden (46) demonstrated that no change took place in blood cholesterol when the cows recovered by udder inflation.

It is the hypocalcaemia theory, therefore, that has stood the test of time, and there is ample evidence that low serum Calcium levels exist in this disease (4, 11, 12, 13, 14, 21, 24, 28, 31, 34, 40, 41, 48, 52, 59, 60, 61, 62, 69, 72, 73, 75, 79, 80, 82, 84, 88, 94). Consequently, replacement therapy was tried, with very successful results. The first salt used was Calcium Chloride (63), which gave

good results, but is extremely irritant to the tissues, and Calcium Gluconate was therefore brought into use (39). Even this was found to be irritant, and nowadays, Calcium Borogluconate (25, 47) is the salt generally employed and can be given subcutaneously if necessary. Udder inflation is still used on occasion and appears to act by increasing blood Calcium levels (29, 41, 69, 72, 73, 88, 94).

With the majority of cases of milk fever occurring within a few days of calving (55), the question arose as to whether a serum Calcium deficiency could be detected in normal cows, and if so, whether its onset was slow or sudden. Reports are variable, but there would appear to be little doubt that a fall in Calcium level does occur (3, 4, 12, 13, 14, 17, 24, 29, 33, 34, 40, 41, 42, 59, 60, 74, 75, 80, 82). (Those workers who did not observe it possibly did not take sufficient samples, as the changes in Calcium are transitory.) The cause of the low Calcium levels is difficult to explain, but it has been attributed by some to the sudden onset of lactation, with the consequent sudden demand by the milk for blood Calcium (24, 63).

Within a very short time of these low serum Calcium levels being found, blood phosphates were being investigated, since Calcium and Phosphate were known to be closely linked (29). This work soon revealed that low Inorganic

Phosphate levels exist in cases of milk fever (14, 29, 30, 31, 48, 52, 69, 72, 73, 79, 80, 82, 84, 88, 94), and it was also shown that these, as well as the serum Calciums, increase as a result of udder inflation (29, 30, 31, 69, 72, 73, 88, 94). In the case of cows calving normally, once again different opinions exist (3, 14, 17, 29, 33, 48, 52, 65, 71, 74, 80, 82, 94), but there is no doubt that where sufficient samples were taken, a decrease could be observed. This was noticed to be greater in old cows than in young ones (94).

Because of the remarkable response of milk fever cases to Calcium therapy, little attention was paid to the blood phosphate levels, until the use of Acid Sodium Phosphate injection was advocated in those cases which do not respond satisfactorily to Calcium therapy alone (7). Shortly afterwards, Robertson (72, 73) presented evidence that the low plasma Inorganic Phosphates in milk fever cases increased as the animals recovered, but did not increase in those which failed to respond to Calcium therapy. By inflating the udders of the latter cows, increases in Calcium and Phosphate took place, and the animals recovered.

It was these observations which led to the work presented here. As a basic step, the normal plasma phosphate picture was ascertained throughout the parturient phase, when the majority of milk fever cases occur (55).

These findings are given in Section I. Milk fever cases are discussed in Section II, from the point of view of initial phosphate levels, and also with regard to the changes in these levels after treatment by Calcium injection or udder inflation. In Section III, the various forms of treatment now in use are examined in detail, to determine whether they have the same effect in normal cows as in milk fever cows. An effort is also made to elucidate the mechanisms by which these treatments work. In the last section, consideration is given to the aetiology of the changes occurring in normal calving cows, for if milk fever is an exaggeration of a normal physiological process (1, 3), these findings may apply equally to milk fever cases.

Most of the previous work on plasma phosphate has dealt solely with Inorganic Phosphate. In the experiments reported here, Total Acid Soluble, Lipid, and Total Phosphates in the plasma were estimated. This was principally to ensure that changes observed in Inorganic Phosphate were not just a transference of phosphate from this fraction to another, but really did reflect a general fall in plasma phosphate level.

B. GENERAL MATERIALS AND METHODS.

SAMPLING.

Blood samples were drawn from either the mammary or jugular veins. Approximately 90 ml. was taken each time, 30 ml. being collected and allowed to clot at room temperature for Calcium estimation, and 60 ml. being oxalated for estimation of the Phosphate fractions.

APPARATUS.

Before use, all apparatus was cleansed, rinsed twice with distilled water, and dried in an oven.

METHODS OF ESTIMATION.

All determinations were carried out in duplicate, and if the results differed by more than 5% from their mean, the estimations were repeated. The vast majority showed a much smaller deviation than this.

Serum Calcium was estimated as soon as the serum had separated from the clot. The method adopted was the Clark-Collip Modification of the Kramer-Tisdall Method (16).

Plasma Phosphates. Phosphate estimations were carried out on plasma, so that the Inorganic Phosphate could be determined as soon after sampling as possible. Because of the distances between farms and the laboratory, a delay of one to two hours was often inevitable before the estimations could be started, but it was generally possible to complete the Inorganic Phosphate analysis within about four hours.

Even samples collected during the night usually conformed to this, although occasionally they were placed in the refrigerator until the next day.

Inorganic Phosphate was estimated by Fiske and Subbarow's colorimetric method (32), the colour being read in a Spekker photo-electric cell against a reagent blank.

The Total Acid Soluble Phosphate estimation was adapted from the method described by Greenhill and Pollard (37) for grass. The actual process used was as follows.

Two ml. of plasma was added to 8 ml. 10% Trichloroacetic Acid, mixed, and filtered through a No. 42 Whatman filter paper. Five ml. of the filtrate was pipetted into a Royal Worcester porcelain crucible (deep type, 11 or 16 ml. capacity) and 1 ml. of 10% Magnesium Nitrate plus a trace (about 1 mgm.) of Magnesium Oxide was added. The crucible was then placed on a hot plate in the fume cupboard until the contents had evaporated to dryness, when ashing was carried out over an open flame. When the ash had cooled, 2.5 ml. of 10 N Sulphuric Acid was added and the crucible placed on the hot plate again. It was left there until the Sulphuric Acid just started to fume, after which it was allowed to cool, distilled water was added and the contents were washed into a 25 ml. graduated flask, no filtering being necessary. The phosphate was

then estimated by "blueing-up", as in the Fiske and Subbarow method for Total Acid Soluble Phosphate, and reading the intensity of colour in a Spekker photo-electric cell. The amount of phosphate was then calculated from a standard graph which was prepared by analysing standard phosphate solutions in the same manner.

Lipid Phosphate was estimated by adding 1 ml. of plasma to 18 ml. of Alcohol-Ether mixture while shaking it in a boiling tube graduated at 20 ml. This was then placed in a boiling water bath for one minute. After cooling, the contents were made up to 20 ml. with the Alcohol-Ether mixture and filtered through a No. 42 Whatman filter paper. Ten ml. of the filtrate was placed in a 16 ml. capacity (deep type) Royal Worcester porcelain crucible, with 1 ml. of 10% Magnesium Nitrate and a trace of Magnesium Oxide. The process followed then was exactly as described under Total Acid Soluble Phosphate.

Total Phosphate was estimated by pipetting 0.5 ml. of plasma into a Royal Worcester porcelain crucible (deep type, 11 ml. capacity) and adding 1 ml. of 10% Magnesium Nitrate, and a trace of Magnesium Oxide. After this, the estimation was as described for Total Acid Soluble Phosphate, but there are some points of special note. Before ashing, the contents of the crucible were thoroughly dried. The most efficient method found was to place the crucible on a

thermostatically controlled hotplate set at 60°C. When the contents of the crucible turned brown on top, the temperature was raised to 100°C. for about half an hour. Then, on commencing to ash, the crucible was placed over a small flame at first, and the heat was gradually increased. By these means, it has been found that loss of the contents through spurting was reduced to a minimum. Another essential point is to ash thoroughly, otherwise the resulting discoloration upsets the intensity of colour on "blueing-up".

REAGENTS.

All reagents were prepared as described under the appropriate references.

ACCURACY OF ORGANIC PHOSPHATE ESTIMATIONS.

Some observations on the accuracy of this method of estimation are given in Appendix III.

STATISTICAL ANALYSES.

t tests, correlation coefficients, and analyses of variance were carried out as described by Goulden (35). Missing values in tables of variance were calculated according to Snedecor (90).

C. EXPERIMENTAL.

SECTION I. BLOOD PHOSPHATES IN NORMAL COWS.

(a) Introduction.

In 1934 and again in 1947, Allcroft expressed the view that the changes occurring in parturient paresis (milk fever) are pathological exaggerations of changes occurring at normal parturition (1, 3). In view of this, and the observation by Robertson (72, 73) that hypophosphataemia may be a complicating factor in some cases of milk fever, it was decided to carry out a detailed study of the physiological changes at parturition, especially with regard to the various phosphate fractions.

Considerable information has already been accumulated on the changes in Inorganic Phosphate during parturition, but little is known regarding the other fractions. The first information came from Meigs and Blatherwick (65), who showed that the blood Inorganic Phosphate of cows after calving was lower than that of their calves. Further information was given by Robinson and Huffman in 1926 (74), who recorded an increase in Inorganic Phosphate from calving, to a peak at 6 - 18 hours after calving.

Sjollema (82) in 1928 took one sample from each of eight cows between eleven and thirty-six hours after calving, and showed four of them to have lower Inorganic Phosphate levels than normal. Two years later,

Palmer et al (71) recorded a drop in Inorganic Phosphate in six cows. This drop ranged from 1.3 to 3.2 mgm. %, and occurred within the last three days prior to calving. The decrease took place largely in the last day and low levels sometimes lasted for several days. Later, in 1932, another two normal calvings were recorded by Seekles et al with similar results (80). That same year, Wilson and Hart (94) observed that the Inorganic Phosphate may fall sometime within three days before calving and that the drop was greater in old cows; Godden and Allcroft (33) showed a low point at calving with a steady rise over the next five days.

In 1934, Allcroft and Godden (3) studied the changes in serum Calcium, Magnesium and blood Inorganic Phosphate, taking daily samples during the parturient period and found a drop in Inorganic Phosphate at calving. On the other hand, Hayden (48) took one sample from each of nine cows within two days after calving, and did not observe any marked change from normal values. Duckworth and Godden (26) recorded a drop in Inorganic Phosphate which they attributed to a fall in the Ultrafiltrable Calcium Complex; the Non-Ultrafiltrable Calcium Complex also changed with the Inorganic Phosphate. Finally, Hibbs (52), taking samples four weeks, and twelve hours before calving, and twelve hours and one week after calving, showed a drop in plasma Inorganic Phosphate at calving; Blosser and

Smith (14) while studying the alterations in the urinary excretion of phosphate, observed similar changes.

The other fractions examined in this paper are the Total Acid Soluble, Lipid and Total Phosphates. Little work has been reported on these, but Meigs et al (66) recorded a drop in Lipid Phosphate as the cow ended her lactation, a low level during her non-lactating phase, and an increase during early milk secretion. Later, in 1933, Little and Mattick (59, 60) showed that there was a drop in serum Total Phosphate at calving in heifers, but Hayden (48) is the only person who has attempted a full phosphate analysis. His results, however, can be criticised on the grounds that sampling was too infrequent to show up any transient changes.

The experiments reported here were intended to fill in some of the gaps in our knowledge of blood phosphate changes, especially in Organic Phosphate fractions, at parturition. For this reason frequent sampling was adopted. Also, since this work is concerned with the relation of physiological changes at parturition to the aetiology of milk fever, the cows have been divided into calving groups, (first calving, second calving, etc.) as it is known that milk fever increases in frequency with advancing age or number of parturitions (1, 51, 55).

As a preliminary step, however, it was felt desirable to ascertain the normal daily changes in plasma phosphates,

Table 1. Normal Plasma Phosphates (Mgms. P./100 ml. Plasma) over Five Consecutive Days. (Averages of Nine Cows.)

Days.	Inorganic Phosphate.	Total Acid Soluble P.	Lipid Phosphate.	Total Phosphate.
1	5.45	5.99	7.62	13.61
2	5.26	6.07	7.86	13.81
3	5.41	6.12	7.91	13.69
4	5.32	6.15	7.70	13.67
5	5.41	6.03	7.70	13.61
Mean.	5.38	6.80	7.75	13.68
S.E.	0.139	0.150	0.099	0.156
Sig.	N.S.	N.S.	N.S.	N.S.

to ensure that the changes observed at parturition do not normally occur at other times. Normal values have frequently been given (30, 50, 65, 84), but the work of Palmer et al (71) is notable for the records of normal day to day fluctuations in individual cows.

(b) Materials and Methods.

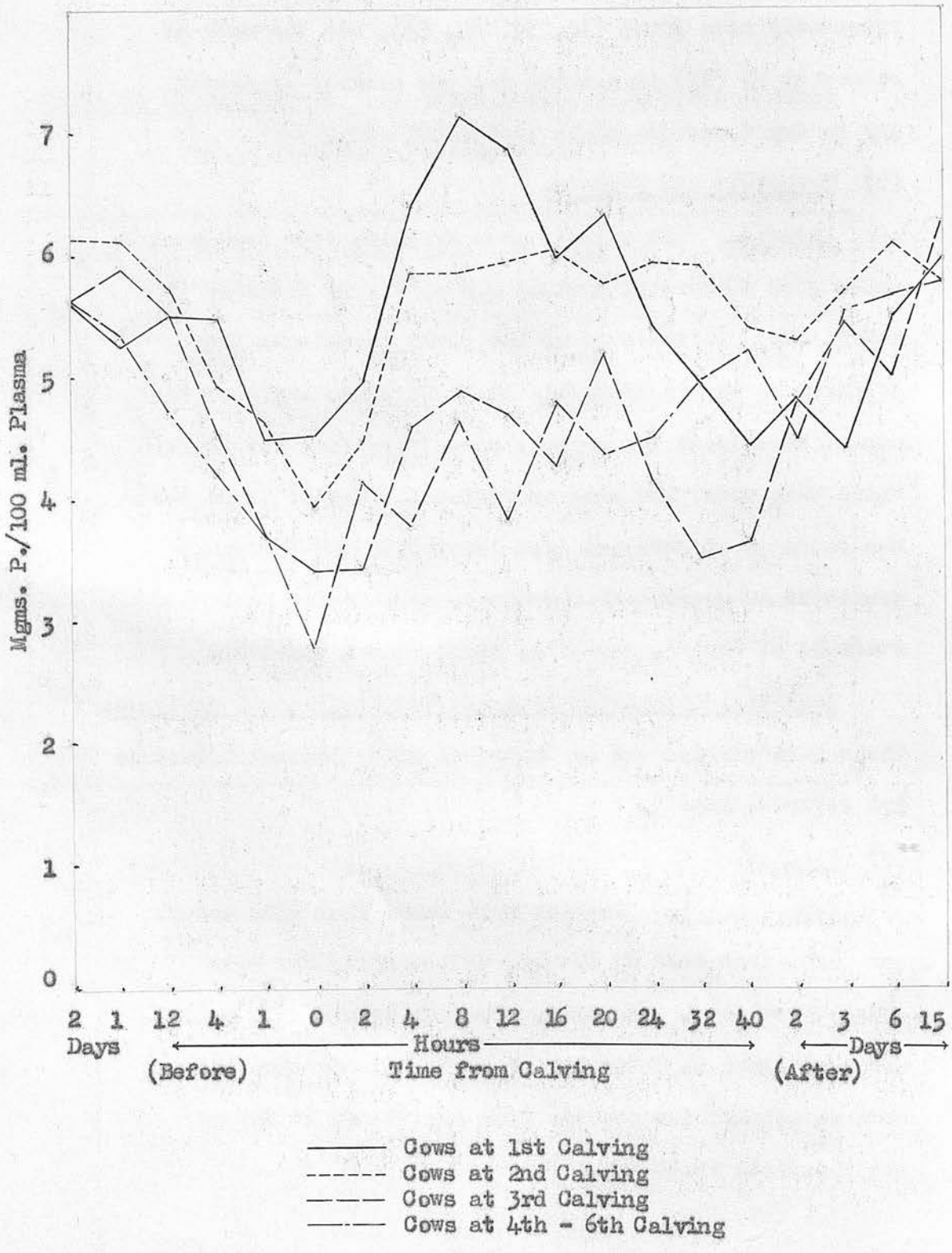
Animals. All animals were Ayrshire type cows kept under good commercial systems and on a high plane of nutrition. In the case of the first experiment they belonged to the Department's Field Station, while in the second experiment the animals were drawn from two herds which were under the same management. One of these herds was composed of pedigree Ayrshire cattle and the other consisted of commercial Ayrshires, some having marked evidence of Jersey, Red-Poll, or Shorthorn breeding.

Sampling, Methods of Analysis and Statistical Analysis. These were carried out as described under General Materials and Methods, page 6.

(c) Results.

Experiment 1. Samples were taken from nine normal non-parturient cows at 10 a.m. each morning for five consecutive days. Results, given in Appendix I, p. ii, are summarised in Table 1. It will be seen that there were no significant changes from day to day in any of the phosphate fractions.

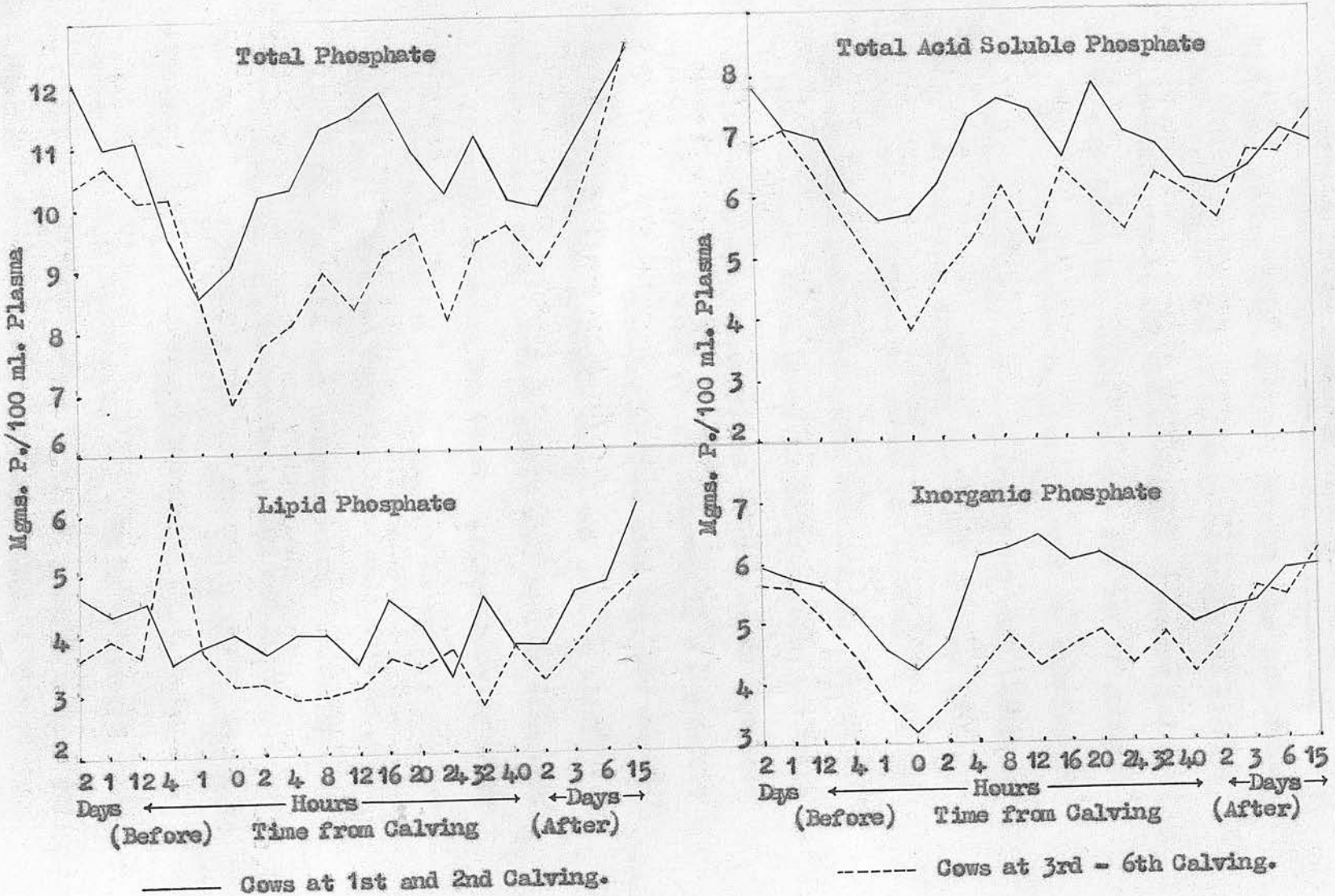
Figure 1. Plasma Inorganic Phosphate Levels
in Normal Parturient Cows.



Experiment 2. Blood samples were taken from thirty-two cows through the parturient period, and full results are given in Appendix I, pp. iii - xii. The missing values in the tables are due to two reasons: firstly, it was not easy to predict the exact date of parturition and time the samples accordingly; and secondly, when the majority of the milk fever cases were found to occur in the first two days post-partum, it was decided to increase the number of samples during that phase. Eventually, samples were taken every four hours for the first day after calving and every eight hours for the second. These results in Appendix I are summarised in Tables a - e in Appendix II, pp. liii - lvii, the number or cows entering into each calculation being shown.

Table a gives the values obtained for Inorganic Phosphate divided into First, Second, Third and Fourth-to-Sixth calving groups. These are shown in Figure 1. The means prior to two days before calving are not given, as they show no significant deviation from this two day value. Since samples from all the cows do not enter into all the means, comparisons, in any group, of the changes occurring from one period of time to the next are liable to be biased. Accordingly, the main value of these figures is to show the differences in levels between the various calving groups.

Figure 2. Plasma Phosphate Levels in Normal Parturient Cows.



It can be seen that, two days before calving, the groups had approximately the same means. As calving approached, these means gradually separated, so that at parturition, they were arranged in order, the cows at their first calving having the highest mean of 4.51 mgm. % and the fourth-to-sixth calving group averaging 2.79 mgm. %. The second and third calving cows show means of 3.94 and 3.41 mgm. % respectively. The differences between the first and third, and the first and fourth-to-sixth calving groups, were significant at 5%. These relative positions were maintained for approximately sixteen hours, when the means gradually merged, so that two days after calving there was no visible difference. A noticeable feature was the close similarity of the first and second calving cows throughout the series, while the means of the third and fourth-to-sixth calving cows formed a distinct but separate group.

In view of this and of the small number of animals used the results were regrouped as in Table b. Here the cows at their first and second calving form one group and those at their third-to-sixth calving comprise the other. These means are shown in Figure 2. Also in the same figure are the means of Total Acid Soluble, Lipid and Total Phosphates for these groups. The details for these fractions are given in Tables c - e, Appendix II, together with the significance of differences between the groups (t test).

Table 2. Plasma Phosphate Changes in Normal Parturient Cows.

(Mgms. P./100 ml. Plasma)

Time from Calving.	Inorganic P.		T.Acid Sol.P.		Lipid P.		Total P.	
	Calving I&II.	III-VI.	Calving I&II.	III-VI.	Calving I&II.	III-VI.	Calving I&II.	III-VI.
2 d. before.	5.98	5.52	7.60	6.78	5.77	3.42	12.53	10.36
Calving.	4.68	3.32	5.78	3.87	4.83	3.26	10.33	7.08
4 h. after.	6.63	4.24	7.47	5.09	4.73	2.94	12.13	7.94
24-40 h. after.	6.10	4.28	7.00	5.80	5.70	2.86	12.65	8.54
2 d. after.	4.93	4.29	5.81	5.38	5.38	3.26	10.83	8.82
10-20 d. after.	5.73	6.18	6.38	7.59	7.30	4.68	13.03	12.88
No. of Cows.	5	9	3	5	3	5	3	5
Mean.	5.68	4.64	6.67	5.76	5.62	3.40	11.92	9.27
S.E.	0.351	0.305	0.486	0.504	0.405	0.405	0.563	0.369
Sig.	1%	1%	N.S.	1%	5%	N.S.	5%	1%

The Inorganic, Total Acid Soluble and Total Phosphates all showed similar trends. Before calving, there were no significant differences between the first and second calving cows, and the third-to-sixth calving cows, but at calving the Inorganic and Total Acid Soluble Phosphates both showed significant differences. The difference in Total Phosphate between these groups was barely significant at this stage.

Post-partum, the first and second calving cows showed higher Inorganic Phosphate levels than the older cows, until thirty-two hours after calving. The Total Acid Soluble Phosphate also showed occasional significant differences between the groups but these were not so marked as for the Inorganic Phosphate and lasted only for about twenty-four hours. In the case of the Total Phosphate, significant differences lasted only twenty hours, with one point at twelve hours where it was barely significant.

Between two and fifteen days after calving, there was no evidence of differences between the groups of any of these phosphate fractions. The Lipid Phosphate also showed no significant differences at any time.

As pointed out earlier, it would be misleading to use the means in Tables a - e to compare the changes from one period of time to the next, in any calving group. Accordingly, from the Tables in Appendix I, pp. iii - xii,

Table 3. Plasma Phosphate Changes before Calving in Normal Parturient Cows.

(Mgms. P./100 ml. Plasma)

Time before Calving.	Inorganic P.		T.Acid Sol.P.		Total P.	
	Calving		Calving		Calving	
	I & II.	III-VI.	I & II.	III-VI.	I & II.	III-VI.
2 days.	6.03	5.68	7.60	7.21	12.53	11.40
1 day.	5.94	5.24	7.20	6.83	12.43	10.94
12 hrs.	5.54	4.89	6.98	6.26	11.50	10.60
Calving.	4.46	3.22	5.78	4.11	10.33	7.50
No. of Cows.	7	6	3	4	3	4
Mean.	5.49	4.76	6.89	6.10	11.70	10.11
S.E.	0.229	0.258	0.434	0.419	0.596	0.230
Sig.	1%	1%	N.S.	1%	N.S.	1%

Table 4. Plasma Phosphate Changes after Calving in Normal Parturient Cows.

(Mgms. P./100 ml. Plasma)

Time after Calving.	Inorganic P.		T.Acid Sol.P.		Total P.	
	Calving		Calving		Calving	
	I & II.	III-VI.	I & II.	III-VI.	I & II.	III-VI.
Calving.	4.30	3.06	4.80	3.73	8.93	6.94
4 hrs.	6.24	3.79	7.54	4.96	10.83	7.68
12 hrs.	6.34	4.31	7.56	5.41	11.93	8.54
24-40 hrs.	5.32	4.61	6.55	6.15	11.21	8.96
No. of Cows.	5	7	4	5	3	5
Mean.	5.55	3.95	6.61	5.06	10.73	8.03
S.E.	0.182	0.360	0.198	0.408	0.384	0.382
Sig.	1%	5%	1%	1%	1%	1%

data from those cows sampled at all the apparently major points in relation to calving are given on pp. xiii - xiv, Appendix I and are summarised in Table 2. To give more detail on the drop in plasma phosphates before calving, similar tables have been drawn up in Appendix I, p. xv and summarised in Table 3. Similarly, Table 4 gives more information on the changes after calving (Appendix I, p. xvi).

Cows at their first and second calving. Broadly speaking, the Inorganic, Total Acid Soluble and Total Phosphates showed the same movement. There was an initial drop from two days before calving until calving, which was significant in the case of Inorganic Phosphate (difference greater than 3 times the Standard Error), but not significant for the other two fractions (Table 3). In the case of Inorganic Phosphate, the drop amounted to 1.57 mgm. per 100 ml., of which 69% took place within the last twenty-four hours. Corresponding figures for Total Acid Soluble and Total Phosphates were 1.82 and 2.20 mgm. per 100 ml. and 66% and 53% respectively. These drops were followed by very marked increases to pre-calving levels at four hours after calving, which were highly significant for all fractions (Table 4). Twelve hours after calving the values reached were virtually the same as those found at four hours for Inorganic and Total Acid Soluble Phosphates,

but the Total Phosphate showed another marked increase at this phase. After this plasma phosphate levels fell until two days after calving, when values approximating those found at calving were observed in all cases (Table 2). At ten-to-twenty days after calving the levels had largely reverted to their pre-calving values.

The Lipid Phosphate also showed a slight drop before calving which was not significant, but the lowest observed point occurred four hours after calving. The only big change from the pre-calving level was the mean of the samples taken ten-to-twenty days after calving, which showed a marked increase over the preceding samples.

Cows at their third to sixth calving. Once again, the Inorganic, Total Acid Soluble and Total Phosphates showed the same trends. There was a fall in phosphate level from two days before calving until calving, which was highly significant in all fractions (Table 3) and was markedly greater than the drop observed in cows at their first and second calving. This fall in level was 2.46, 3.10 and 3.90 mgm. % for Inorganic, Total Acid Soluble and Total Phosphates respectively. The bulk of this drop occurred in the last twenty-four hours, the percentages then being 67.9, 69.5 and 77.5.

The changes after calving were also markedly different from those in the younger group of cows. Although there

Table 5. Serum Calcium Changes in Normal Parturient Cows.

(Mgms. Ca./100 ml. Serum)

	Section (a).		Section (b).	
No. of Cows.	3	5	5	9
Time from Calving.	Calving I & II.	Calving III-VI.	Calving I & II.	Calving III-VI.
2 d. before.	10.01	11.24	10.29	11.01
Calving.	9.92	8.98	10.16	9.07
4 h. after.	9.88	8.91	10.36	9.01
24-40 h. after.	8.75	9.42	9.38	9.33
2 d. after.	9.27	9.44	9.56	9.76
10-20 d. after.	9.68	10.33	10.28	10.63

was an increase in level at four hours after calving, it was twelve hours before significant increases were detected for any of the fractions (Table 4). Despite these increases, however, the values were still lower than the pre-calving levels, even at two days after calving. It was ten-to-twenty days before normality was attained, although if more samples had been taken, normal values would probably have been obtained earlier than this.

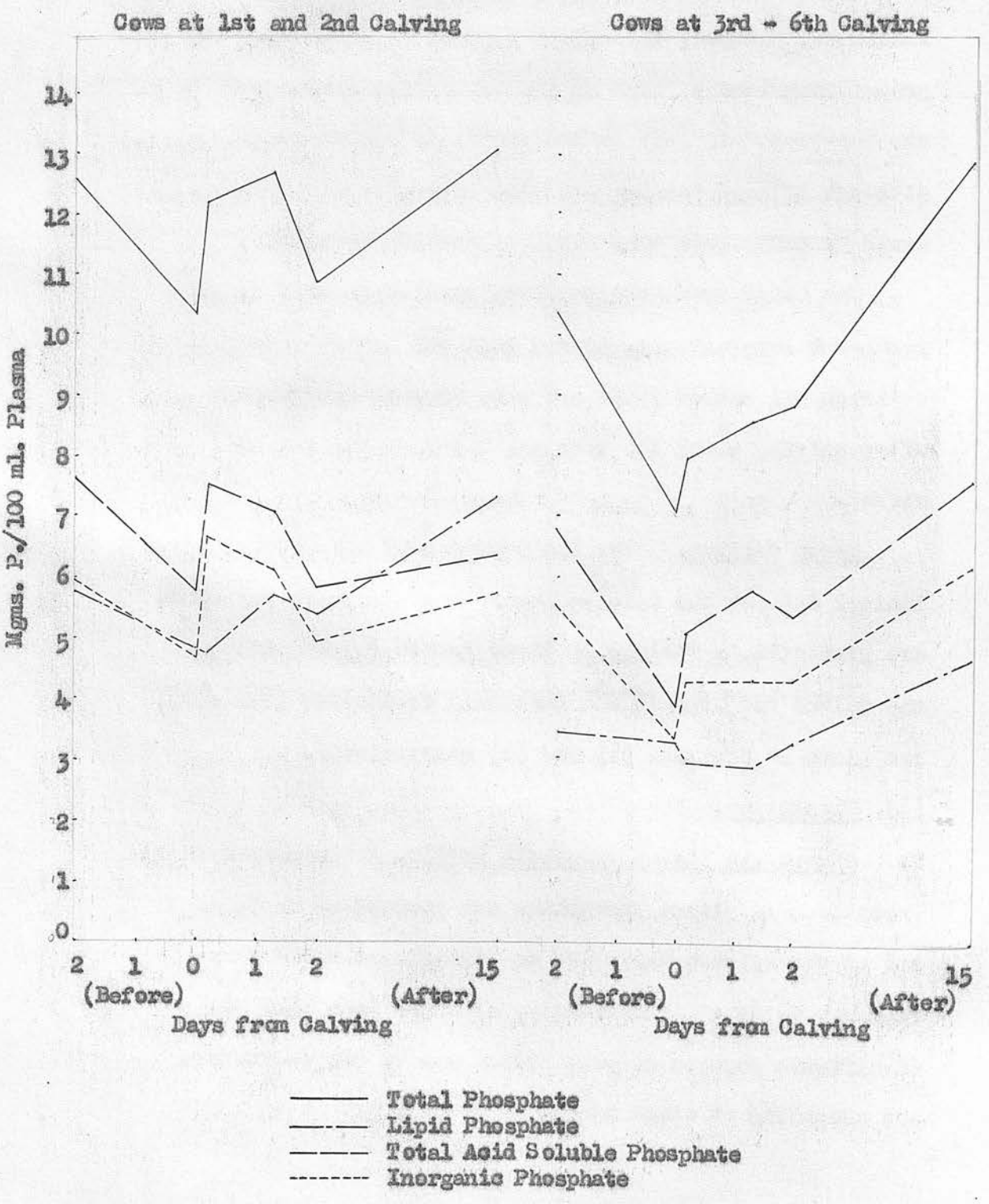
The Lipid Phosphate was very similar to that in the younger calving groups, except that the lowest point observed was rather later - twenty-four-to-forty hours after calving - and the terminal increase was not so marked.

Serum Calcium. For the purposes of this paper, only limited data on the Calcium levels are necessary and these are presented in Table 5. Those levels corresponding to the values for Organic and Inorganic Phosphates (Table 2), are given in Sections (a) and (b) respectively.

(d) Discussion.

1. Changes in plasma phosphate levels. The normal daily variations in plasma phosphates are summarised in Table 1 and it can be seen there are no significant differences from day to day. Accordingly, it would seem that all significant changes at parturition may be due to factors not operating at other times.

Figure 3. Plasma Phosphate Changes in Normal Parturient Cows.



So far, there has been little evidence in the literature to indicate whether or not the plasma or serum Total Phosphate levels alter at normal parturition. Only three articles have been found dealing with this aspect, of which two (59, 60) show no evidence of any alteration, while the other (48) suggests that a fall in serum Total Phosphate does occur. Without definite information on this point, it is impossible to say that the Inorganic Phosphate alterations at calving are not merely an interchange of phosphate from one fraction to another.

From Figure 3 it will be seen that in the cows at their first and second calvings, there are two marked decreases in the level of Total Phosphate, with two compensating increases. The first decrease occurs as the cow approaches calving and is largely due to a fall in Total Acid Soluble Phosphate. Lipid Phosphate also plays a small part in this reduction. After calving, the Total Phosphate level is restored by an increase in the Total Acid Soluble Phosphate level for the first four hours, and then by an increase in the Lipid Phosphate until about thirty-two hours after calving. These changes lead to both the Total and the Total Acid Soluble Phosphates reaching their pre-calving levels within eight hours of calving. Two days after calving there is a second reduction in the Total Phosphate almost to the level observed at calving,

due to both the Total Acid Soluble and Lipid Phosphates falling, but again the former drops more. This time it is the Lipid Phosphate which plays the major part in returning the Total Phosphate to its pre-calving level.

The majority of the changes observed in the Total Phosphate are due to changes in Total Acid Soluble Phosphate and examination of Figure 3 shows that the latter is composed largely of Inorganic Phosphate, so the fall in this fraction may be the cause of the other low plasma phosphate levels. Similarly, the changes in the Total Phosphate of cows at their third-to-sixth calving are largely attributable to alterations in the Inorganic Phosphate. Unlike the cows at earlier calvings, there is only one decrease in Total Phosphate which occurs before calving, and is due exclusively to loss in the Total Acid Soluble Phosphate. This is followed by a gradual increase in Total Phosphate over the whole period of the investigation, until ten-to-twenty days after calving when the value observed is significantly higher than that observed before calving. On the other hand, even two days after calving, the Total Phosphate is still significantly lower than its pre-calving level; indeed, only about half the phosphate reduction prior to calving is restored. The reason for this continued low level in Total Phosphate would appear to be the relatively small increase in Total Acid Soluble

Table 6. Calcium/Phosphate Ratio Changes in Normal Parturient Cows.

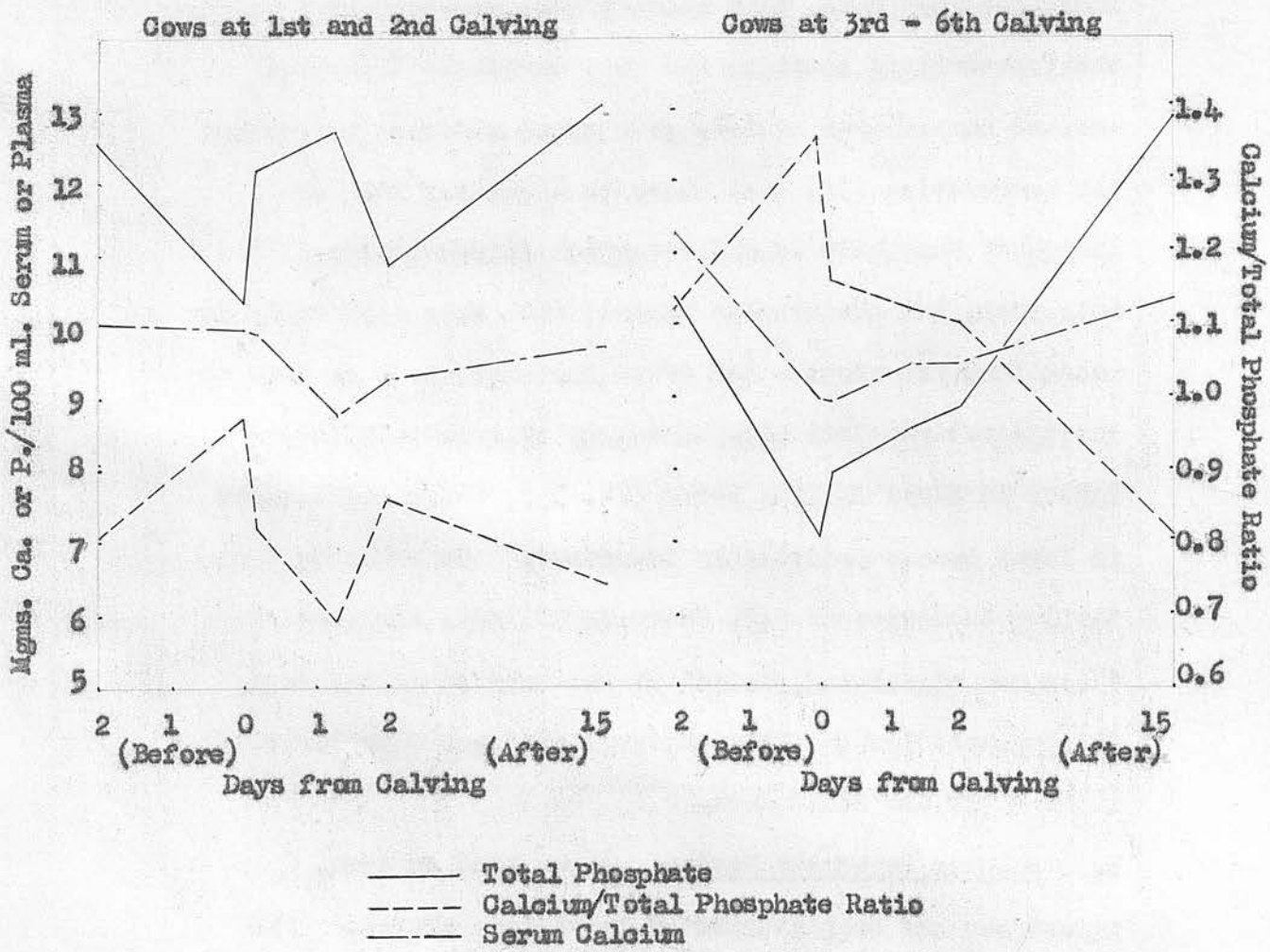
Time from Calving.	Ca./Inorganic Phosphate		Ca./Tot. Acid Sol. Phosphate		Ca./Total Phosphate	
	I & II.	III-VI.	I & II.	III-VI.	I & II.	III-VI.
2 d. before.	1.73	2.04	1.32	1.73	0.81	1.12
Calving.	2.21	2.98	1.77	2.43	0.97	1.36
4 h. after.	1.57	2.45	1.33	1.83	0.82	1.16
24-40 h. after.	1.58	2.17	1.26	1.65	0.69	1.12
2 d. after.	1.93	2.49	1.64	1.76	0.86	1.10
10-20 d. after.	1.81	1.71	1.52	1.38	0.74	0.81
No. of Cows.	5	8	3	5	3	5
Mean.	1.81	2.31	1.47	1.80	0.81	1.11
S.E.	0.095	0.231	0.148	0.193	0.044	0.054
Sig.	1%	1%	N.S.	5%	5%	1%

Phosphate after calving, compared with its large fall before calving. The Total Acid Soluble Phosphate is the only source of the change in Total Phosphate until two days after calving, when both this and the Lipid Phosphate contribute to the increase.

Some of these changes in phosphate, especially in Inorganic Phosphate, have already been recorded, but so far the frequency of sampling has been much less than that adopted here. Our results give ample evidence to confirm the observation (94) that there is a greater fall in Inorganic Phosphate in old cows than in young ones. Not only that, but the results suggest that this difference is maintained for about a day after parturition. In view of the indications that phosphates may be a complicating factor in cases of milk fever (72, 73), these differences in level become potentially important. It could be that the low incidence of milk fever in heifers, and cows at their second calving, is due to the very rapid recovery in phosphate levels after calving, compared with the slow increase in the older cows.

2. Calcium/Phosphate Ratios. From time to time, importance has been attributed to various ratios. The most prominent one in milk fever and grass tetany is the Calcium/Magnesium ratio (6, 57, 83, 84), while the Calcium/Phosphate ratios have not been extensively studied.

Figure 4. Serum Calcium, Total Phosphate, and Calcium/Total Phosphate Ratios in Normal Parturient Cows.



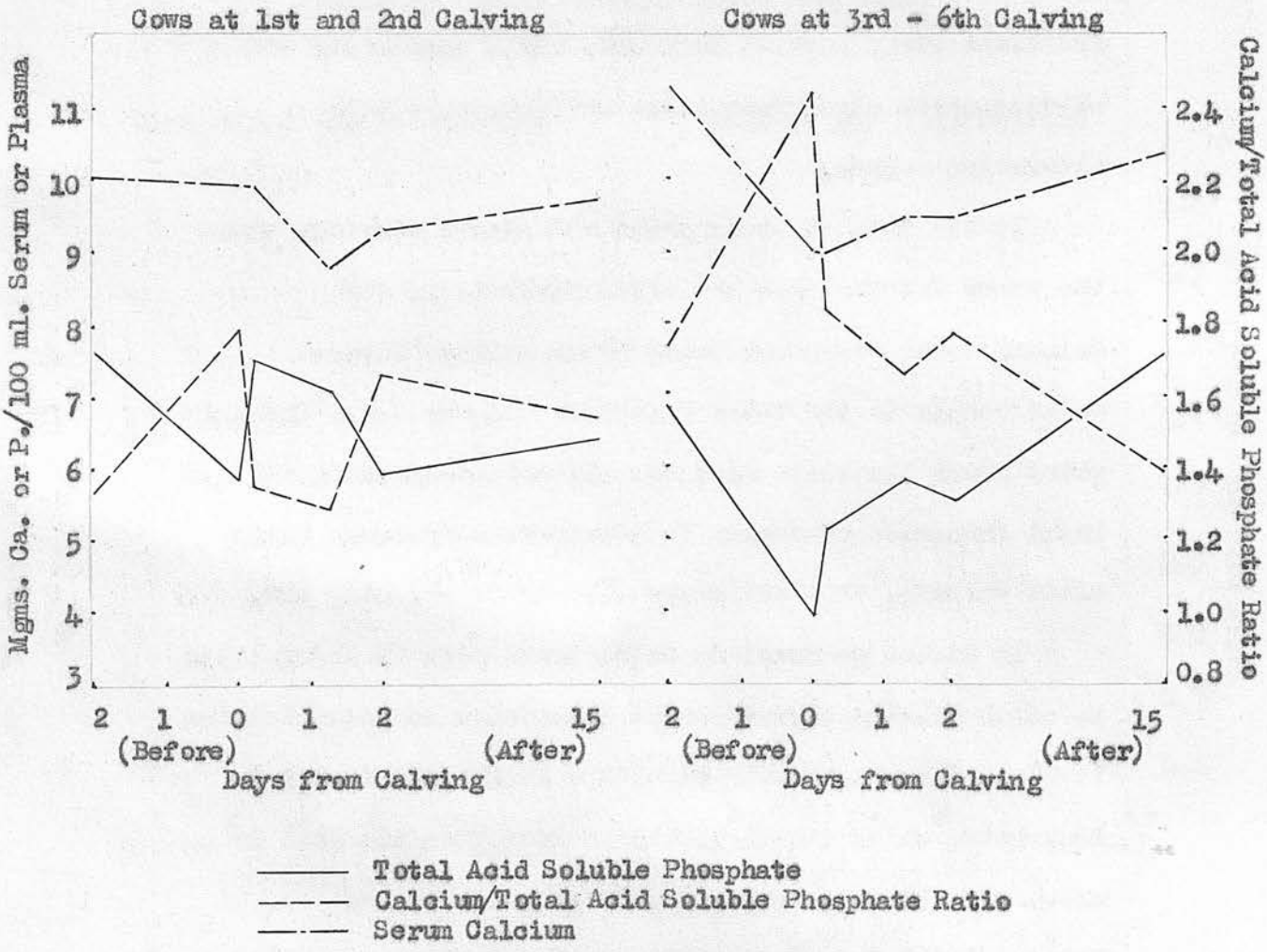
Fish (29) is the only person to mention these, but draws no conclusions regarding their significance.

The Calcium/Total Phosphate ratios for the results reported above are given in Appendix I, pp. xvii - xviii and summarised in Table 6. With the exception of a very transient rise, lasting only from about four hours before calving until about four hours afterwards, little alteration occurs.

In the cows at their first and second calving, since the serum Calcium does not alter materially, the Calcium/Total Phosphate ratio shows a close inverse relationship to the Total Phosphate (Figure 4). The only point where the ratio does not closely reciprocate the Total Phosphate movements is twenty-four-to-forty hours after calving, when the serum Calcium is slightly low.

In direct contrast to this, those cows at their third to sixth calving show a marked depression in serum Calcium level. This is associated with a large drop in Total Phosphate, which is relatively greater than the fall in serum Calcium; consequently, an increase in the Calcium/Total Phosphate ratio occurs. Within four-to-eight hours of calving, however, the ratio, which is still associated with low values of both serum Calcium and Total Phosphate, returns to its pre-calving level. These values gradually increase throughout the period of the experiment, while the ratio slowly falls.

Figure 5. Serum Calcium, Total Acid Soluble Phosphate and Calcium/Total Acid Soluble Phosphate Ratios in Normal Parturient Cows.

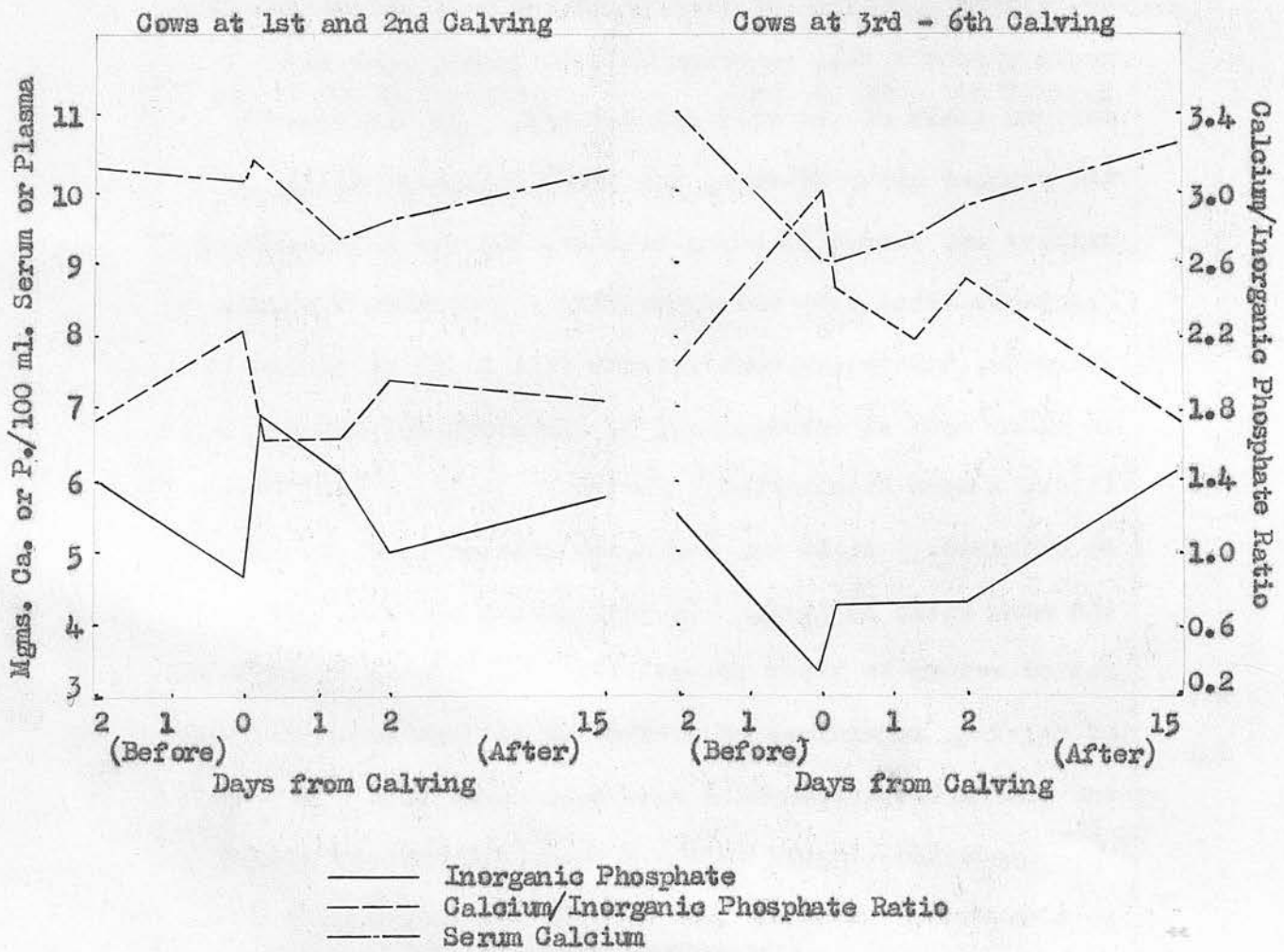


This data suggests that the Calcium/Total Phosphate ratio may be held within fairly narrow limits, the maximum being in the region of 1.36 - the highest ratio observed (Table 6). If this is so, any decrease in Total Phosphate would induce a fall in serum Calcium level, once the maximum limit of the ratio is reached. In the case of the younger group of cows, the Total Phosphate falls without any change in serum Calcium, but the Calcium/Total Phosphate ratio does not approach the suggested maximum. There is, however, a much greater fall in Total Phosphate in older cows at calving and, if the serum Calcium did not alter, a mean Calcium/Total Phosphate ratio of 1.67 would be obtained. As it is, the serum Calcium level falls and the mean ratio is 1.36. In both groups of cows, these ratios return to their pre-calving level within eight hours of calving, regardless of whether or not the serum Calcium and plasma Total Phosphate return to normal.

Since the changes in Total Phosphate are mainly due to alterations in Total Acid Soluble and Inorganic Phosphates, these Calcium/Phosphate ratios are presented in Appendix I, p. xix and are summarised in Figures 5 and 6 and Table 6.

The Calcium/Total Acid Soluble Phosphate and the Calcium/Inorganic Phosphate ratios alter during the same phase as the Calcium/Total Phosphate ratio. In order to

Figure 6. Serum Calcium, Inorganic Phosphate and Calcium/Inorganic Phosphate Ratios in Normal Parturient Cows.



ascertain which of these shows the least variation, the relative stability of each ratio was determined by calculating the percentage increase in the ratio, from two days before calving until calving, with the following results:-

Ratio ..... Calcium/	Total Phosphate.	Total Acid Soluble P.	Inorganic Phosphate.
Calvings I and II....	19.8%	34.1%	27.7%
Calvings III - VI....	21.4%	44.9%	46.1%

These figures show that the Calcium/Total Acid Soluble and Calcium/Inorganic Phosphate ratios increase more than the Calcium/Total Phosphate ratio which would suggest that the latter is the more likely ratio to be concerned in any such hypothetical regulatory mechanism.

(e) Summary.

1. There was a drop in plasma Total Phosphate at parturition, which was greater in cows at their third to sixth calving than in those at their first and second calving.

2. There was a marked recovery in plasma Total Phosphate within eight hours of calving in the younger cows and the peak was reached within twelve-to-sixteen hours. This was followed by a fall in Total Phosphate at two days after calving, and a return to normal at ten-to-twenty days.

3. The older cows showed a slow recovery after calving - in two days only half the drop had been made good - but recovery was complete at ten-to-twenty days.

4. These alterations were due mainly to changes in the Total Acid Soluble Phosphate which in turn were due largely to the Inorganic Phosphate.

5. The difference in level after calving, between the cows at their first and second calving and those at their third-to-sixth calving is discussed in relation to milk fever.

6. Lipid Phosphate tended to reach a low point during the parturient period.

7. There appeared to be a fairly definite Calcium/Total Phosphate ratio, which increased temporarily for a few hours at calving. The changes in the ratios were similar for both calving groups.

8. The Calcium/Total Acid Soluble Phosphate and the Calcium/Inorganic Phosphate ratios were fairly constant, but had relatively higher deviations at calving than the Calcium/Total Phosphate ratio.

9. It is postulated that the drop in the Total Phosphate in the younger cows was not sufficient to induce an alteration in serum Calcium, but that it was sufficient in the older cows.

SECTION II. BLOOD PHOSPHATES IN PARTURIENT PARESIS.

(a) Introduction.

As indicated earlier, the literature on the serum Calcium levels in cases of milk fever is considerable and the effect of Calcium therapy has been fairly extensively studied (25, 31, 39, 40, 41, 42, 60, 63, 72, 73, 82). The effect of treatment by udder inflation has also been investigated and there is little doubt that an increase in serum Calcium is the result (29, 41, 69, 72, 73, 88, 94).

The position with blood phosphates however, is much more obscure, and the work is confined largely to Inorganic Phosphate. Sjollema (82) was the first to publish findings on this aspect by recording thirty-six cases of milk fever: most of these had low Inorganic Phosphate values, but a few values were normal and one was higher than normal. He treated twenty of these cases by Calcium Chloride injection, but did not take further samples and consequently could give no data on the phosphate levels after treatment. Fish (29, 30, 31), in a series of papers during the next two years, verified this low blood Inorganic Phosphate, and also drew attention to low Total Acid Soluble Phosphates in such cases. After treatment by udder inflation, he found that the phosphates increased a little in ten to twenty minutes and in six to eight hours they had reached normal values. He pointed out that

recovery of these cows apparently coincided with the phosphates reaching normal values, even although the Calcium levels were not normal, but he did not comment on which ion he considered to be the more important.

In 1930, Sjollema and Seekles (84) gave the Inorganic Phosphate values in milk fever cases as 2.16 mgm. % on average, compared with 4.57 mgm. % for normal cows. Seekles, Sjollema and van der Kaay (79, 80) recorded two more cases, in both of which they found that the Inorganic Phosphate had reached a lower level at calving than that found at the time of milk fever. One of their cases was sampled after treatment by parathyroid injection and showed an increase in Inorganic Phosphate until recovery. Wilson and Hart (94) also found low Inorganic Phosphates associated with low serum Calciums in five cases of milk fever, but they considered the Calcium deficiency, rather than the low phosphate, to be the essential cause of the condition.

Little and Mattick (60) found low Total Phosphate in three cases of milk fever, and Hayden (48) suggested that there is a drop in all phosphate fractions (Inorganic, Total Acid Soluble, Lipid and Total) in such cases. Hibbs (52), studying the effect of feeding yeast for the prevention of milk fever, also recorded low Inorganic Phosphate levels.

Smith and Neidermeier (88) studied the effect of udder inflation on five cases of milk fever, and reported that the Inorganic Phosphate did not reach normal levels within twenty hours of treatment, in four of the cows. In 1950 they reported seven cases which responded to udder inflation (69) and showed that the Inorganic Phosphate had not reached normal levels when the animals recovered. Both these observations are contrary to those reported by Fish (29, 30).

Robertson (72, 73) again drew attention to the low levels of Inorganic Phosphate in milk fever cases, and also suggested its importance in the response of these cases to Calcium therapy. He found that the Inorganic Phosphate did not increase if the cows failed to respond to treatment, but that they recovered when the Inorganic Phosphate increased to normal levels as a result of either Calcium therapy or udder inflation.

Blosser and Smith (14), studying the possible increased excretion of phosphate in milk fever cases, also found low Inorganic Phosphate values.

While low Inorganic Phosphate values exist in cases of milk fever, the information on the other phosphate fractions is too scanty to permit any conclusions being formed. There is no indication whether these levels are lower than those occurring normally at calving, so their importance

is not clear. Further, with the exception of two papers (72, 73), there is no data on the phosphate changes occurring after treatment by Calcium. With a view, therefore, to obtaining more information on these points, as many cows as possible have been sampled before and after treatment by Calcium Borogluconate.

Investigations have also been conducted in a few cases that were treated by udder inflation. Wright, in the discussion of a paper by Greig (43), expressed the opinion that those cows which do not respond to Calcium injection would not respond to udder inflation either, but some case reports would tend to disprove this view (72, 73). Indeed, so convincing was the recovery to udder inflation in some cases where Calcium therapy had failed, that a further aim of this investigation was to see if any differences between the changes in plasma phosphates could be detected after these two forms of treatment.

(b) Materials and Methods.

Animals. The selection of animals was purely at random, as all cases of milk fever occurring in the School's practice during the period of this investigation are recorded here. The majority of the cases occurred in Ayrshire cattle, as that was the predominant breed in the area.

Sampling. Blood samples were taken, either from the mammary or less frequently from the jugular vein, immediately prior to treatment. Samples after treatment were at irregular intervals, and of irregular occurrence. Generally, however, a sample was taken at fifteen to thirty minutes and a third sample at a period varying from one to twenty-nine hours, but usually four to ten hours, after the completion of treatment. A few cows were followed in more detail, from three to seven samples being obtained within a period of ten hours of treatment.

Methods of Treatment. Treatment followed the usual clinical lines and consisted either of 4 ounces of Calcium Borogluconate given intravenously in 400 - 500 ml. water, or of inflation of the mammary gland with air.

Analysis of Blood and Statistical Analysis. These were carried out as indicated under General Materials and Methods, page 6.

(c) Results.

For the purposes of this section, each treatment is regarded as a separate case, even though individual cows may have received more than one treatment. However, any treatment which occurred while the blood levels appeared to be under the influence of a previous treatment, that is within about ten hours, is not included, nor is any case where the diagnosis was doubtful. Full details are given in Appendix I, pp. xx - xxxii.

Table 7. Comparisons between the Plasma Phosphates and the Calcium/Phosphate Ratios of Milk Fever and Normal Cows.

Cows.		Inorg. P.	Tot.Acid Sol.P.	Lipid P.	Total P.
Milk Fever before Treatment.	No. of Cows.	82	82	82	82
	Mean.*	1.51"	2.23"	3.33	5.54"
	± S.E.	0.095	0.135	0.145	0.197
	Ca./P. Ratio.	5.09	2.79'	-	0.96
	± S.E.	0.862	0.184	-	0.040
Normal Cows III-VI, 16-24 hours after Calving.	No. of Cows.	16	8	7	8
	Mean.*	4.65	6.22	3.21	9.10
	± S.E.	0.237	0.585	0.593	0.465
	No. of Cows.	15	8		8
	Ca./P. Ratio.	2.02	1.58	-	1.02
	± S.E.	0.111	0.138	-	0.076

' Difference from Normal Cows Significant at 5%.

" Difference from Normal Cows Significant at 0.00001%.

* Mgms. P./100 ml. Plasma.

i. Time of treatment of milk fever cases in relation to calving. The average time of treatment of the eighty-two cases of milk fever was 20.47 ± 2.10 hours after calving, and since the majority of these cases were first treatments, the times given will not deviate markedly from the time of onset of milk fever. Sixty-nine of these cases were treated by an injection of Calcium Borogluconate and of these, forty-one responded Satisfactorily (see iv below). The average time of treatment of these cases was 27.24 ± 2.90 hours after calving, while the twenty-eight that gave an Unsatisfactory response were treated at 10.68 ± 2.53 hours. The difference between these times is significant at 0.01% (t test).

ii. Phosphate levels in milk fever cases. The means and Standard Errors of the phosphate fractions of the eighty-two cases of milk fever are given in Table 7. As the average sampling time of these cases was 20 hours after calving, their phosphate values were compared with the values obtained for normal cows at sixteen-to-twenty-four hours after calving. All phosphate fractions, with the exception of Lipid Phosphate, were significantly lower than normal.

In view of their suggested importance in the previous section, the Calcium/Phosphate ratios are also given. These show that the Calcium/Inorganic Phosphate and the Calcium/Total Phosphate ratios in milk fever cases did not

differ significantly from normal, although there was a fairly wide difference between the means of the former. The Calcium/Total Acid Soluble Phosphate ratio was significantly higher in the milk fever cows than in the normal cows.

iii. Phosphate changes preceding milk fever. Unfortunately, samples were obtained from only four cows prior to the onset of milk fever, two of which were pre-partum milked. The data are too meagre to be analysed statistically, but inspection of the Table (Appendix I, p. xx) shows that there was little change in plasma phosphates until calving, when the levels fell as in normal cows. In those cases where milk fever did not occur at calving, there were slight increases in phosphate levels until four-to-eight hours after calving. After this the levels tended to fall until milk fever developed. Lipid Phosphate appeared to follow the pattern for normal cows.

iv. Response to Calcium therapy. Many of the cases treated by an intravenous injection of four ounces of Calcium Borogluconate either relapsed some hours after apparent recovery, or did not respond at all. Accordingly, these cows have been classified as giving an Unsatisfactory response, as opposed to those that recovered rapidly (viz. within ten hours, without relapse) which is termed a Satisfactory response. All told, forty-one cows giving

Table 7. Comparisons between the Plasma Phosphates and the Calcium/Phosphate Ratios of Milk Fever and Normal Cows.

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	± S.E.	0.237	0.585	0.593	0.465
	No. of Cows.	15	8		8
	Ca./P. Ratio.	2.02	1.58	-	1.02
	± S.E.	0.111	0.138	-	0.076

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In view of their suggested importance in the previous section, the Calcium/Phosphate ratios are also given. These show that the Calcium/Inorganic Phosphate and the Calcium/Total Phosphate ratios in milk fever cases did not

Table 9. Increases in Plasma Phosphates in Milk Fever Cases giving Satisfactory (S) and Unsatisfactory (U) Responses after Treatment with Calcium Borogluconate.

Plasma P.		Increase at 15-30 mins.		Increase at Third Sample.	
		Response S.	U.	Response S.	U.
	No. of Cows.	23	15	17	10
Inorganic	Mean.*	0.73	0.69	1.73	0.81
	± S.E.	0.126	0.133	0.186	0.239
	Difference.	Not Sig.		Sig at 1%	
Total Acid Soluble	Mean.*	1.10	0.55	2.11	0.97
	± S.E.	0.146	0.156	0.188	0.220
	Difference.	Sig. at 5%		Sig. at 0.05%	
Lipid	Mean.*	-0.01	0.00	0.04	0.12
	± S.E.	0.108	0.118	0.135	0.117
	Difference.	Not Sig.		Not Sig.	
Total	Mean.*	0.97	0.53	2.16	1.14
	± S.E.	0.175	0.175	0.235	0.251
	Difference.	Not Sig.		Sig. at 1%	

* Mgms. P./100 ml. Plasma

From this data, Table 9 gives the increases in phosphates occurring after the injection of Calcium Borogluconate, the significance of the differences being calculated by t test.

With the exception of the Total Acid Soluble fraction, the phosphate increases in both the Satisfactory and Unsatisfactory groups were about the same at 15 - 30 minutes after treatment. Even in the case of Total Acid Soluble Phosphate, the difference was rather small and only significant at 5%. At the Third Sample, however, the position had altered, as all fractions, except the Lipid Phosphate, showed a significantly greater increase in the Satisfactory than in the Unsatisfactory response group.

More frequent sampling was carried out on twenty-three cows, eleven giving Satisfactory, and twelve Unsatisfactory, responses (Appendix I, pp. xxi - xxiv). The times of sampling of five cows in each group were 15 and 30 minutes, and 1, 2, 4, 6 and 10 hours after treatment, in addition to a pre-treatment sample. An analysis of variance was carried out on these, one missing value having been calculated, and results are given in Table 10. In the Unsatisfactory group, there were gradual rises in all three phosphate fractions until about two hours after treatment, when these remained level or dropped slightly. In these animals, only the Inorganic Phosphate can be regarded as

Table 10. Serum Calcium, Plasma Phosphates and Calcium/Phosphate Ratios in Milk Fever Cases treated with Calcium Borogluconate and giving Satisfactory (S) and Unsatisfactory (U) Responses. (Means of five cows.)

Time from Treatment.	Calcium.* S.	U.	Inorganic P.* S.	U.	Tot. Acid Sol. P.* S.	U.	Total P.* S.	U.	Calcium / Inorg.P. S.	U.	Calcium / T.Ac.Sol.P. S.	U.	Calcium / Total P. S.	U.
Before Treatment.	3.49	4.02	1.22	1.10	1.45	1.71	5.08	5.18	4.23	4.30	4.20	2.54	0.73	0.85
After Treatment.														
15 m.	9.76	14.59	2.09	1.54	2.35	2.33	5.81	5.70	5.47	11.89	6.92	7.57	1.70	3.03
30 m.	9.10	11.63	2.15	1.54	2.40	2.54	6.02	5.98	5.28	8.46	5.67	5.11	1.53	2.24
1 h.	8.15	10.44	2.24	2.16	2.42	2.90	6.18	6.40	4.41	6.03	4.14	3.98	1.34	1.95
2 h.	7.30	8.91	2.28	2.25	2.66	2.96	6.48	6.66	4.39	4.99	3.72	3.75	1.18	1.52
4 h.	6.41	7.44	2.38	1.85	3.18	2.79	6.55	6.04	3.75	5.13	2.27	3.04	1.02	1.43
6 h.	6.16	6.94	2.43	1.79	3.13	2.95	6.48	6.04	2.82	6.03	2.05	2.91	0.97	1.33
10 h.	5.84	5.74	3.59	1.72	3.98	2.63	7.72	6.64	1.66	4.91	1.50	2.88	0.70	1.01
Mean.	7.03	8.71	2.30	1.74	2.68	2.59	6.29	6.08	4.00	6.47	3.81	3.97	1.15	1.67
S.E.	0.679	0.630	0.229	0.198	0.286	0.255	0.302	0.276	0.586	1.046	1.028	0.710	0.093	0.218
Sig.	1%	1%	1%	1%	1%	5%	1%	5%	1%	1%	1%	1%	1%	1%

There is one calculated plot on each series. According to Snedecor (90), differences significant at 5% should be regarded as Not Sig.

* Mgms. Ca. or P./100 ml. Serum or Plasma.

showing a significant increase. The cows which gave a Satisfactory response showed a very similar picture until two hours after treatment, but the increase in phosphates continued afterwards and the highest observed point was the last one at 10 hours. These changes are significant. Lipid Phosphate showed no consistent trend in either group.

Figures for Calcium levels before and after treatment are also given. The two groups followed a similar course, with the Unsatisfactory response group having rather higher values; those at 10 hours after treatment, however, were essentially identical.

In view of their possible importance, the Calcium/Phosphate ratios are given for the same twenty-three cows (Appendix I, pp. xxvii - xxix). An analysis of variance has been carried out on five cows in each group, as shown in Table 10.

v. Treatment by udder inflation. Only twelve treatments by udder inflation have been studied and of these, one case relapsed, while another did not rise after treatment (Appendix I, pp. xxx - xxxi). Eight samples, with one exception, were collected from each of five of these cows, the times of sampling being the same as for treatment by Calcium (viz. before, and 15 and 30 minutes and 1, 2, 4, 6 and 10 hours after treatment). Phosphate estimations

Table 11. Plasma Phosphates and Calcium/Phosphate Ratios in Milk Fever Cases, treated by Udder Inflation.
(Means of five cows.)

Time from Treatment.	Inorg. P.*	Tot.Acid Sol.P.*	Lipid P.*	Total P.*	Calcium Inorg.P.	Calcium T.A.S.P.	Calcium Total P.
Before treatment.	0.74	1.26	2.31	3.26	9.45	4.69	1.67
After treatment.							
15 m.	1.33	1.63	2.53	4.08	4.91	4.17	1.57
30 m.	1.80	2.28	2.57	5.02	3.82	3.24	1.33
1 h.	1.83	3.36	2.43	5.90	43.62	2.54	1.25
2 h.	2.99	3.96	2.38	6.34	1.26	2.18	1.25
4 h.	3.90	4.32	2.46	6.86	2.16	1.98	1.13
6 h.	2.84	4.04	2.76	6.84	1.45	1.85	1.13
10 h.	4.03	4.55	2.68	7.26	2.13	1.72	1.05
Mean.	2.43	3.18	2.52	5.70	8.60	2.80	1.30
S.E.	0.455	0.372	0.168	0.343	14.707	0.391	0.114
Sig.	1%	1%	N.S.	1%	N.S.	1%	1%

* Mgms. P./100 ml. Plasma.

Significant increases took place in Inorganic, Total Acid Soluble and Total Phosphates, but not in Lipid Phosphate. The increases were rapid at first and gradually slowed down, the highest values being at ten hours after treatment, but the Inorganic Phosphate was depressed at six hours after treatment.

The Calcium/Inorganic Phosphate ratio was very erratic, but the Calcium/Total Acid Soluble Phosphate and Calcium/Total Phosphate ratios declined steadily , as the Phosphates were increasing relatively faster than the Calcium (Appendix I, p. xxxii, and Table 11).

(d) Discussion.

Plasma Phosphates prior to Treatment. In the past, workers studying the phosphate values in milk fever cases have tended to compare them with normal values assessed for non-parturient cows (30, 82). Since there is ample evidence, however, that plasma phosphates are depressed in cows at normal calving, especially in older cows, a similar drop in phosphate level in milk fever cases would probably be of little significance, while one of a greater magnitude could be important. The mean time of sampling of the milk fever cases was twenty hours after calving, so comparison of phosphate levels in milk fever cases with normal values at that time is logical. Highly significant differences for Inorganic, Total Acid Soluble and Total Phosphates were

found to exist (Table 7). The Lipid Phosphate shows no significant difference, and the drop of this constituent observed by Hayden in milk fever cases (48) is probably no greater than that which normally occurs.

In the previous section, the suggestion was made that the serum Calcium and plasma Phosphate levels are linked in some way, possibly by a mechanism controlling the Calcium/Phosphate ratios. If this is the case a similarity between the mean ratios in milk fever cases and normal cows would be added support for the claims of any particular ratio to be regarded as of importance. Accordingly, it would seem unlikely that the serum Calcium and plasma Total Acid Soluble Phosphate are interdependent, as there is a significant difference between the Calcium/Total Acid Soluble Phosphate ratios of the milk fever and normal cows. Either the Inorganic Phosphate or the Total Phosphate, however, might be influencing the Calcium (Table 7) and of these, the mean Total Phosphate ratios are more similar (0.96 and 1.02, compared with 5.09 and 2.02 for the Inorganic Phosphate ratios).

The deviations of the ratios from the means are also worth considering, as a large variation would tend to cast doubt on the existence of an effective regulatory mechanism based on that particular ratio. Here again the evidence suggests that the Calcium is more likely to be linked to

Total Phosphate, as the Calcium/Total Phosphate ratio has smaller Standard Errors (0.040 and 0.076) than the Calcium/Inorganic Phosphate ratios (0.862 and 0.111).

If this hypothesis is correct the essential cause of milk fever would seem to be a diminution in plasma Total Phosphate, leading to a fall in serum Calcium. It has already been shown that the Total Phosphate in cases of milk fever is lower than the levels normally encountered at calving (Table 7), but at this time the plasma phosphate levels are usually increasing. Reference to the data in Appendix I, p. xix, however, would indicate that no increase in Total Phosphate takes place, and it would seem, therefore, that milk fever may be attributed to a failure of the Total Phosphate to increase after calving.

In the previous section, the opinion was expressed that the bulk of the changes in Total Phosphate in normal cows at parturition are due to alterations in Total Acid Soluble Phosphate, and these in turn to the Inorganic Phosphate. The same is equally true here, where the Lipid Phosphate is normal, and the drop in Total Phosphate before calving, and its failure to increase after calving, are due to changes in Total Acid Soluble Phosphate. Since the nature of the phosphate changes before the onset of milk fever are similar to those occurring in normal cows at calving, it may be that the same factors are responsible in both cases.

Table 12. Distribution of Initial Phosphate Levels within Twenty-four Hours after Calving, in Relation to Response to Calcium Therapy.

	Inorganic Phosphate		Total Acid Soluble Phosphate	
Mean of Unsatisfactory Group....	1.06		1.64	
Response.....	Satis.	Unsatis.	Satis.	Unsatis.
Cases over mean.....	10	6	13	5
Cases under mean.....	6	12	3	13

The presumptive evidence in favour of the hypothesis that phosphate is an important aetiological factor in the milk fever syndrome raises the question as to whether there are any detectable differences in the initial blood levels of these constituents, in relation to their response to treatment (Table 8). Although, on taking all the cases together, there are no differences in initial levels for any of the phosphate fractions, the results indicate that low initial Inorganic and Total Acid Soluble Phosphates within twenty-four hours after calving are associated with cases that will not respond Satisfactorily to Calcium therapy. More detailed study of these cases (Table 12) shows that in the case of the Inorganic Phosphate, 37.5% of cases with values over the mean of 1.06 gave Unsatisfactory responses, and 33.3% of cases with values under the mean responded Satisfactorily. The Total Acid Soluble Phosphate gives slightly better results, only 27.8% of the cases with initial levels over the mean of 1.64 responding Unsatisfactorily, and 18.8% under the mean responding Satisfactorily. From this it would seem that four cases in five occurring within twenty-four hours after calving and having a Total Acid Soluble Phosphate value of less than 1.64, will relapse after Calcium therapy.

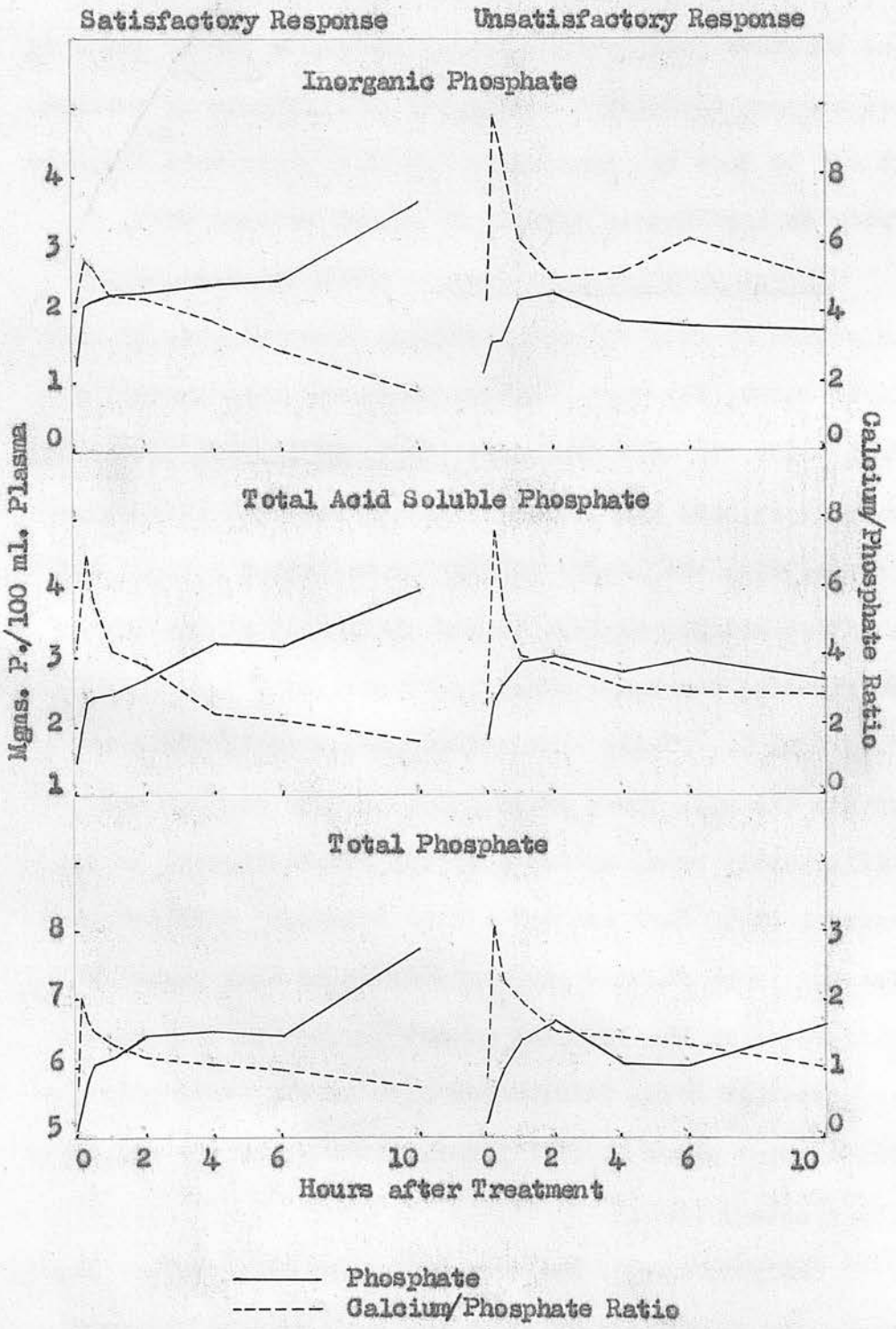
Of cases occurring before calving, six out of seven relapsed, with phosphates ranging from high to low. After twenty-four hours from calving, only four cases in

twenty-five relapsed, although there are cases with very low phosphate levels which responded Satisfactorily. Why these cases should respond, when there are many cases in the previous period with similar phosphate levels which do not respond to Calcium treatment, is difficult to explain. It may be that the phosphates are at a phase when they are ready to increase as they do in normal calving cows.

Effect of Calcium therapy. After the intravenous injection of four ounces of Calcium Borogluconate in milk fever cases, the serum Calcium rises and then gradually falls over the next ten hours (Table 10). The levels are similar in both the Satisfactory and Unsatisfactory response groups, with the latter tending to be rather higher, but the most notable feature is the similarity of the levels attained at ten hours after treatment, viz. 5.84 and 5.74 mgm. %. While such values are generally held to be within the milk fever range (41), all the cows in the Satisfactory group and some in the Unsatisfactory group, were on their feet and apparently normal. Another point is that these figures give no indication that there is any difference in the response of the groups and they rather suggest that serum Calcium may have little to do with the fundamental cause of milk fever, although it may influence the symptoms (78).

The phosphates, however, are quite different. Lipid Phosphate shows no consistent changes, but the Inorganic,

Figure 7. Plasma Phosphates and Calcium/Phosphate Ratios in Milk Fever Cases, treated with Calcium Borogluconate.



Total Acid Soluble and Total Phosphates all show the same trends. In the case of the cows that responded Unsatisfactorily, Figure 7 and Table 10 show the plasma phosphates increased for two hours and then either remained level, or decreased. The cows that responded Satisfactorily, however, were very similar to this until the two hours, but their phosphates continued to increase for ten hours. Although the means in the two groups are similar, until two hours after treatment, some of the cows giving an Unsatisfactory response had negligible increases in plasma phosphate while those that responded Satisfactorily all showed considerable increases as a result of Calcium therapy (Appendix I, pp. xxi - xxiv). This is in accord with previous observations (72, 73).

To test whether the increases in phosphate until ten hours after injection differ between the two groups, t tests were carried out on values from the twenty-three cows in Appendix I, pp. xxi, xxii and xxiv, from which the cows in Table 10 were drawn. Eighteen have values for ten hours after treatment, and the results are as follows:-

	Satisfactory Response.			Unsatisfactory Response.			
	N.	Mean.	S.E.	N.	Mean.	S.E.	Sig.
Inorganic P.....	10	2.12	0.250	8	0.53	0.287	1%
Tot. Acid Sol. P...	10	2.21	0.313	8	0.78	0.368	1%
Total P.....	10	1.89	0.386	8	1.06	0.506	N.S.

Only the Inorganic and Total Acid Soluble Phosphates show significant differences in their increases, but the Total Phosphate also shows a significant difference when examined on a wider scale (Table 9). This Table also shows significant differences in the increases in Inorganic and Total Acid Soluble Phosphates in the same period, thus corroborating the evidence given above. The differences in the increases at 15 - 30 minutes after treatment are not significant, except for the Total Acid Soluble Phosphate, where it is just significant.

There can be little doubt that the increases in phosphate after treatment were due to the Calcium injected, and an explanation can be given on the basis of the Calcium/Phosphate ratios. On the assumption that these ratios have a maximum limit, it would be reasonable to suppose that, on injection of Calcium, not only would the Calcium be eliminated from the blood as rapidly as possible, to reduce the ratio to normal, but the plasma phosphate would also increase. This process could be expected to continue until the ratio drops to normal.

In the case of the cows giving an Unsatisfactory response, reference to Figure 7 shows that the maximum phosphate level is reached two hours after treatment. At this point, the Calcium/Inorganic Phosphate and Calcium/Total Acid Soluble Phosphate ratios are 4.99 and

3.75 respectively, both of which are markedly higher than any mean values recorded for normal calving cows. The mean Calcium/Total Phosphate ratio at this time is 1.52, which is only slightly higher than the suggested maximum ratio of 1.36 (Section I, p. 24).

The results for the cows which responded Satisfactorily to treatment are more difficult to assess, as there is little indication of the point at which the increases in phosphate cease to be due directly to the injected Calcium. In the case of the Total Acid Soluble and Total Phosphates, there is a slight fall in level after four hours from treatment. Therefore it may be justifiable to consider those values as being the peak levels induced by the Calcium injected. The marked increase from six until ten hours after treatment may be the result of stimulating general metabolism, as at this phase the Calcium levels are low. In the case of the Inorganic Phosphate, it might be fair to assume that the value at two hours after treatment represents the maximum increase induced by the Calcium injection. The Calcium/Phosphate ratios at these peak points are 4.39, 2.27 and 1.02 for Inorganic, Total Acid Soluble and Total Phosphates respectively. Of these, the first is markedly in excess of the mean of any normal value (Table 6), but the other two are normal.

Thus the only ratio which returns to normal in both groups by the time the phosphate has reached its maximum, is

the Calcium/Total Phosphate ratio. This would seem to strengthen the case for assuming that it normally has a maximum limit. This ratio, moreover, returns to normal within one to two hours, whereas the other ratios are high for four or more hours (Table 10).

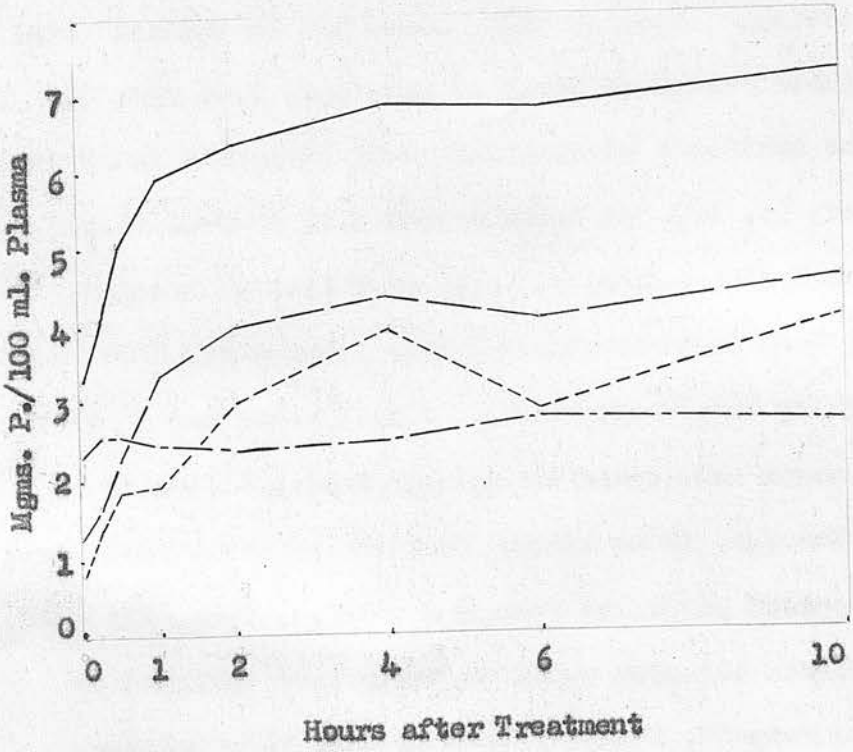
The results suggest that essential features of recovery in cases of milk fever are that the plasma phosphate levels should increase, and that these increases should be maintained for ten hours. That the difference between Satisfactory and Unsatisfactory responses to treatment is one of degree is substantiated by Table 8, where there are differences in their initial phosphate levels. These differences occur in the Inorganic and Total Acid Soluble Phosphates, but it has been suggested that the low serum Calcium levels are due to low Total Phosphate. This is not illogical, as, with the Lipid Phosphate being relatively stable, it is only by changes in level of Inorganic and Total Acid Soluble Phosphates that the major changes in Total Phosphate take place. On the other hand, the general level of Total Phosphate also depends on the Lipid Phosphate, which shows wide variations in level from cow to cow (see p. ii, Appendix I).

Effect of Udder Inflation. Robertson (72, 73) records cases which failed to respond to Calcium therapy, but responded to udder inflation, and this is true of most of

the cases presented here (Appendix I, pp. xxx and xxxi). It is not possible to prove definitely that a treatment with Calcium at the time of udder inflation would not have succeeded in these cases, but some indication can be obtained in ten of our cases which occurred within one day after calving. Five of these cases had an initial Total Acid Soluble Phosphate level of less than 1.64 mgm. %. Using the incidence of Unsatisfactory responses found for this group (p. 40), we would expect that four of these cases would either have relapsed or failed to respond, had they been treated with Calcium. The other five cases had starting levels over 1.64. Since about one in four of similar cases were found to respond Unsatisfactorily to Calcium therapy, it is likely that one of these five would have responded poorly to such treatment. Thus, all told, five of these ten cows would probably have relapsed or failed to respond, had they been treated with Calcium. By treatment by udder inflation, however, only one case gave any trouble.

Two other cases were treated by udder inflation. One was inflated at sixty hours after calving, so the chances are that she would have responded to Calcium therapy, despite three previous treatments. The other case occurred eight hours before calving, and died within twenty-four hours of the onset of the condition, never having responded

Figure 8. Plasma Phosphates in Milk Fever Cases, treated by Udder Inflation.



in the meantime. From the time factor, it is unlikely that she would have responded to Calcium therapy either.

The mechanism of udder inflation is obscure, although more detail will be given in the next section. The Lipid Phosphate showed little change, but the Inorganic, Total Acid Soluble, and Total Phosphates all increased steadily, with a slight pause at six hours, until ten hours after treatment (Figure 8). One of these cases is the cow that died, and the only observed difference between this cow and the others, is that the phosphate levels declined after six hours from treatment. The decrease in the Calcium/Phosphate ratios indicates that the plasma phosphate was increasing faster than the serum Calcium, but since colostrum contains more Calcium than phosphate (as Ca. and P.) (22), this would tend to negative the idea that udder inflation forces the milk Calcium back into the bloodstream.

(e) Summary.

1. Records are given of the initial phosphate levels in eighty-two milk fever cases undergoing treatment.

2. Plasma Inorganic, Total Acid Soluble, and Total Phosphates were lower than values for normal cows at calving, but the Lipid Phosphate was not significantly reduced.

3. There is evidence that the serum Calcium deficiency in cases of milk fever is associated with the plasma Total Phosphate, through a mechanism controlling Calcium/Total Phosphate ratio.

4. Following treatment with Calcium Borogluconate, twenty-eight cases either relapsed, or did not respond (Unsatisfactory response), and forty-one cases responded Satisfactorily. The time of treatment of the former was 10.68 ± 2.53 hours, and for the latter, 27.24 ± 2.90 hours, the difference being highly significant.

5. As in the cows at normal calving, the depression of plasma Total Phosphate was due to a depression in the Total Acid Soluble Phosphate, which in turn was due to a fall in Inorganic Phosphate.

6. Six out of seven cases occurring before calving responded Unsatisfactorily to Calcium therapy. From 0 - 24 hours after calving, four out of five cases with plasma Total Acid Soluble Phosphate values under 1.64 mgm. %, and one in four with values over 1.64 mgm. %, either relapsed, or did not respond. After one day from calving, only four cases in twenty-five gave Unsatisfactory responses.

7. On treating with Calcium, the plasma phosphate levels of cows responding Satisfactorily showed an increase for ten hours at least, but Unsatisfactory cases showed no increase after two hours from treatment. The differences in the increases at ten hours between the groups were highly significant for Inorganic and Total Acid Soluble Phosphates. Serum Calciums were low at the ten hours, and no difference existed between the groups.

8. Udder inflation cured cases which, from predictions based on 6 above, would have responded Unsatisfactorily to Calcium therapy. The changes in plasma phosphates were similar to those occurring after successful treatment with Calcium Borogluconate.

SECTION III. THE EFFECT OF MILK FEVER TREATMENTS ON PARTURIENT AND NON-PARTURIENT COWS.

(a) Introduction.

Although the treatments of milk fever by udder inflation and Calcium injection have been in use for many years now, the success of these methods has been such that very little work on the mechanisms involved in their curative action has been undertaken. Indeed, as low serum Calciums were observed in cases of milk fever, the injection of Calcium salts was regarded as simply replacement therapy and no further explanation appeared necessary. Now, however, in view of the apparent involvement of phosphate, especially in cases which do not respond satisfactorily to Calcium therapy, further study of the action of Calcium on phosphate and the mechanism involved is indicated.

Although injections of Calcium salts have been given to animals (often parathyroidectomised) for experimental purposes in relation to the reciprocal movements of Calcium and phosphate in the blood (38, 81), the work in normal ruminants is extremely limited. In this country, Allcroft (2) injected 82.5 gms. of Calcium Gluconate into cattle and five minutes later observed a rise of 15.3 mgm. % in serum Calcium. This fell progressively and after twelve hours a value lower than the initial level was obtained. He gave no indication of concurrent changes

in phosphate, as he was primarily concerned with Calcium-Magnesium interactions. Craige (18), however, studied the changes in phosphate following Calcium injection in normal parturient and non-parturient cows and found a difference existed between them. Four parturient cows showed a marked rise in Inorganic Phosphate, but the level dropped slightly in his five non-parturient cows. In these latter cows, he assumed that as the Calcium was being excreted it swept the phosphate out of the bloodstream, but in a subsequent paper (20) no increased urinary excretion of Inorganic Phosphate was observed, although Calcium excretion was enormously increased. The increase in Inorganic Phosphate in parturient cows was attributed to alteration in its solubility and excretion due to the acidifying action of Calcium salts, low phosphate being associated with an alkalosis.

It was felt that further work on the lines adopted by Craige might lead to a better understanding of the action of Calcium therapy in milk fever cases and accordingly a series of experiments on parturient and non-parturient cows was initiated, the results of which are given below.

Phosphate injection has been advocated in some cases of milk fever (7) and therefore it was thought desirable that a survey of the effects of such an injection should also be carried out, especially in view of the observation

in non-ruminants (81) that serum Calcium levels are depressed as the result. However, in the previous sections there is evidence that at calving, low plasma phosphate levels may be the cause of low serum Calcium levels and consequently it was felt that phosphate injections at that time might result in an increase in serum Calcium.

(b) Materials and Methods.

Animals. The animals used were Ayrshire dairy cattle which had calved at least twice. All the experiments on parturient cows were started within twenty-four hours of calving, care being taken to ensure that there were no clinical signs of incipient parturient paresis. The non-parturient cows were approximately six weeks from calving, usually before.

Techniques. The calcium injections consisted of four ounces (ca. 120 gms.) of Calcium Borogluconate dissolved in 400-500 ml. of water and injected intravenously, using a flutter valve apparatus. The injection normally took four to five minutes to complete.

The phosphate injections were carried out in a similar manner, two ounces (ca. 60 gms.) of Acid Sodium Phosphate being dissolved in 400-500 ml. of water.

Sampling. Samples were taken immediately before the commencement of the experiment and at 15 and 30 minutes and 1, 2, 4, 6 and 10 hours after the completion of the

Table 13. Serum Calcium and Plasma Phosphate Changes in Normal Cows, injected with Calcium Borogluconate.*
(Means of six cows.)

Time from Injection.	Non-parturient Cows. Serum Calcium	Inorg. P.	Tot.Acid. Sol. P.	Lipid P.	Total P.	Parturient Cows. Serum Calcium	Inorg. P.	Tot.Acid Sol. P.	Lipid P.	Total P.
Before Injection.	10.98	3.88	5.78	5.68	11.43	9.69	3.35	4.55	4.42	8.67
After Injection.										
15 m.	18.77	4.10	6.26	5.44	11.67	17.45	4.57	5.52	4.23	9.28
30 m.	16.89	4.25	6.30	5.43	11.65	16.03	4.98	5.86	4.43	9.75
1 h.	15.23	4.54	6.51	5.24	11.78	14.80	5.03	6.12	4.40	10.15
2 h.	13.39	4.40	6.13	5.28	11.30	12.28	4.63	5.76	4.36	9.77
4 h.	11.98	3.94	5.46	5.15	10.53	11.80	4.12	4.93	4.34	8.92
6 h.	11.23	3.94	5.36	5.23	10.50	10.60	3.53	4.38	4.48	8.48
10 h.	10.95	4.51	5.79	5.30	10.97	9.61	3.10	4.46	4.43	8.60
Mean.		4.19	5.95	5.34	11.23		4.16	5.20	4.39	9.20
S.E.		0.325	0.187	0.137	0.200		0.386	0.388	0.168	0.446
Sig.		N.S.	1%	N.S.	1%		1%	1%	N.S.	N.S.

* Mgms. Ca. or P./100 ml. Serum or Plasma.

injection. If an intravenous injection was being made, the first sample was taken from the jugular vein; in all other cases sampling was from the mammary vein.

Analysis of Samples and Statistical Analysis. These were carried out as described under Materials and Methods, page 6, except that in some cases the Lipid Phosphate was determined by difference between the Total and Total Acid Soluble Phosphates.

(c) Results.

i. Calcium Injections. Six parturient and six non-parturient cows were given a Calcium injection. Detailed results are given in Appendix I, pp. xxxiii and xxxiv. Means and Standard Errors for these serum Calcium and plasma phosphate levels are given in Table 13. The Calcium levels increased by about 8 mgm. % as the result of the injection and fell to the pre-injection level ten hours later. The changes in Inorganic, Total Acid Soluble and Total Phosphates differed in magnitude between the parturient and non-parturient cows, although the trends appeared to be the same. They consisted of an increase in level to one hour after injection which was much greater in the parturient than in the non-parturient cows. This was followed by a fall in phosphate to or below the pre-injection level at four to six hours from injection, after which the changes were not very marked. In the non-parturient cows, the plasma Inorganic Phosphate

Table 14. Calcium/Phosphate Ratios in Normal Cows, injected with Calcium Borogluconate.
(Means of six cows.)

Time from Injection.	Non-parturient			Parturient		
	Ca. Inorg.P.	Ca. T.A.S.P.	Ca. Tot.P.	Ca. Inorg.P.	Ca. T.A.S.P.	Ca. Tot.P.
Before Injection.	3.71	1.94	1.00	3.71	2.23	1.21
After Injection.						
15 m.	5.70	3.00	1.63	4.08	3.32	2.00
30 m.	5.76	2.68	1.48	3.47	2.88	1.73
1 h.	4.30	2.26	1.31	3.59	2.54	1.51
2 h.	3.13	2.19	1.21	3.24	2.39	1.39
4 h.	3.09	2.22	1.18	3.21	2.56	1.35
6 h.	3.16	2.13	1.11	3.18	2.55	1.29
10 h.	3.02	1.94	1.05	3.73	2.24	1.14
Mean.	3.98	2.29	1.24	3.53	2.59	1.45
S.E.	0.656	0.094	0.041	0.494	0.175	0.073
Sig.	5%	1%	1%	N.S.	1%	1%

increased slightly, while the Total Acid Soluble and Total Phosphates tended to revert to their pre-injection level; in the parturient cows all values returned to the pre-injection level. The Lipid Phosphate showed negligible changes in both groups.

The Calcium/Phosphate ratios for these cows are given in detail in Appendix I, pp. xxxv and xxxvi and are summarised in Table 14. Naturally, since Calcium was injected, the ratios showed a marked increase in all cases at the first sample after injection. The Calcium/Total Phosphate ratio showed a steady decline in both parturient and non-parturient cows and had reached its pre-injection level within ten hours. The other ratios followed roughly the same course, but individual Calcium/Inorganic Phosphate ratios varied considerably and their changes are consequently scarcely significant. In all cases the ratios at one hour after treatment are those corresponding to the maximum levels of plasma phosphates after Calcium injection.

ii. Phosphate Injections. Six parturient and six non-parturient cows were injected intravenously with two ounces Acid Sodium Phosphate. These results are tabulated in Appendix I, pp. xxxvii and xxxviii and summarised in Table 15.

The effect of this injection on serum Calcium was constant in all cases, parturient and non-parturient,

Table 15. Serum Calcium and Plasma Phosphate Changes in Normal Cows, injected with Acid Sodium Phosphate.*
(Means of six cows.)

Time from Injection.	Non-parturient Cows. Serum Calcium	Inorg. P.	Tot.Acid Sol.P.	Lipid P.	Total P.	Parturient Cows. Serum Calcium	Inorg. P.	Tot.Acid Sol.P.	Lipid P.	Total P.
Before Injection.	10.96	5.17	5.80	6.29	12.08	9.16	3.51	3.87	3.22	7.08
After Injection.										
15 m.	9.79	14.97	16.14	6.10	21.60	8.24	12.88	13.64	2.11	15.68
30 m.	9.70	12.71	13.53	6.28	19.35	8.01	11.66	12.31	2.45	14.78
1 h.	9.43	10.02	11.22	6.31	17.10	8.01	9.75	10.52	2.50	13.02
2 h.	9.47	7.28	8.12	6.37	14.28	7.88	7.47	8.19	2.79	10.98
4 h.	9.63	6.52	6.84	6.05	13.03	7.90	5.97	6.57	2.85	9.42
6 h.	9.68	5.72	6.27	6.15	12.55	8.01	5.52	6.08	2.79	8.87
10 h.	10.06	5.53	5.93	6.26	12.17	7.76	4.95	5.33	3.10	8.42
Mean.		8.47	9.23	6.21	15.25		7.71	8.31	2.73	11.03
S.E.		0.349	0.455	0.221	0.335		0.288	0.294	0.187	0.273
Sig.		1%	1%	N.S.	1%		1%	1%	1%	1%

* Mgms. Ca. or P./100 ml. Serum or Plasma.

a slight drop being elicited. On the average, the lowest point reached was at one hour after injection. The effect of the injection on the Inorganic, Total Acid Soluble and Total Phosphates followed the obvious lines. There was a marked increase of about 9-10 mgm. %, after which there was a steady decline until the initial level was reached at ten hours after injection. The Lipid Phosphates did not alter.

iii. Udder Inflations. Treatment by udder inflation in cases of milk fever has been used for the last fifty years, but up to date its mode of action has not been satisfactorily explained. One suggestion is that inflation causes reabsorption of Calcium and phosphate from the milk, but there are those who consider that the increases in blood Calcium and phosphate are the result of hormonal stimulation (95). This view is substantiated by the good results obtained from udder inflation in cases of milk fever, even after complete milking out.

The following experiments are concerned principally with the "reabsorption of phosphate from the milk" theory. The principle adopted is that similarity between the blood changes after udder inflation of lactating and non-lactating cows would tend to negative the theory. Accordingly, the udders of twelve non-parturient cows (four non-lactating; four lactating, milked out; and four non-lactating, not milked out) and six parturient cows (lactating, milked

Table 16. Plasma Phosphate Changes in Normal Cows after Udder Inflation.*
(Means of four non-parturient and six parturient cows.)

Time from Injection.	Inorganic P. Non-parturient N.L.	M.O.	N.M.O.	P.	Total Acid Soluble P. Non-parturient N.L.	M.O.	N.M.O.	P.	Lipid P. Non-parturient N.L.	M.O.	N.M.O.	P.	Total P. Non-parturient N.L.	M.O.	N.M.O.	P.
Before Injection.	5.55	5.37	5.58	1.83	5.93	5.51	5.69	3.20	4.75	7.39	7.39	3.12	10.68	12.90	13.08	6.31
After Injection.																
15 m.	6.10	5.80	6.70	3.39	6.63	6.14	6.95	4.49	4.43	7.56	7.40	2.54	11.05	13.70	14.35	7.03
30 m.	6.34	5.73	6.77	2.81	6.64	6.08	7.04	4.50	4.89	7.18	7.49	2.93	11.53	13.25	14.53	7.43
1 h.	6.09	6.13	6.81	3.52	6.31	6.39	6.93	4.96	4.59	6.94	7.50	2.98	10.90	13.33	14.43	7.83
2 h.	5.87	6.11	6.67	3.62	6.25	6.24	7.09	5.43	4.15	6.84	7.06	2.58	10.40	13.08	14.15	8.01
4 h.	5.14	5.75	6.68	3.77	5.44	5.90	6.90	5.76	3.61	6.13	6.70	2.78	9.05	12.03	13.60	8.53
6 h.	5.06	5.66	7.19	4.86	5.24	5.76	7.46	5.97	3.46	5.84	6.59	2.95	8.70	11.60	14.05	8.91
10 h.	5.44	5.26	7.63	4.27	5.70	5.33	7.66	6.38	4.20	6.90	6.84	3.36	9.65	12.23	14.50	9.73
Mean.	5.70	5.72	6.75	3.51	6.02	5.92	6.96	5.09	4.26	6.85	7.12	2.91	10.24	12.76	14.08	7.98
S.E.	0.209	0.296	0.263	0.442	0.215	0.269	0.280	0.305	0.239	0.293	0.214	0.169	0.251	0.211	0.333	0.295
Sig.	1%	N.S.	1%	1%	1%	N.S.	1%	1%	1%	1%	5%	5%	1%	1%	N.S.	1%

N.L. Non-lactating. M.O. Milked out.
N.M.O. Not milked out. P. Parturient, milked out.

* Mgms. P./100 ml. Plasma.

out) were inflated. The inflation was carried out by means of an udder inflation apparatus, until the udder was distended and tense. Tapes were tied round the teats to prevent the escape of air and removed one hour later. The cows were milked out at the next normal milking time, unless that occurred within six hours of inflation, when it was postponed. All the parturient cows were within twenty-four hours of calving at the start of the experiment, while the non-parturient cows were either before or after calving, but not less than a month from calving. The results of these experiments are given in Appendix I, pp. xxxix - xlii and are summarised in Table 16.

Non-parturient, non-lactating cows. Udder inflation caused a transient increase in Inorganic Phosphate until about thirty minutes after inflation, which was followed by a fall to below its initial level at four to six hours; at ten hours it had returned to its normal value. The Total Acid Soluble Phosphate showed an identical picture, but in the case of the Total Phosphate the drop in level was very much accentuated and the level at ten hours after inflation was significantly lower than the initial level. This was due to the Lipid Phosphate, which did not alter until thirty minutes after inflation when it showed a marked decline of 1.43 mgm. % until six hours after inflation. The changes in all these fractions were significant.

Non-parturient cows, milked out before inflation.

The changes in Inorganic and Total Acid Soluble Phosphates were very similar to the foregoing but, because the drop was not so great after the initial increase, none of the changes were significant. The Lipid Phosphate, however, showed the same marked fall as in the dry cows (1.72 mgm. %). As a result, the movements of the Total Phosphate of the non-parturient milked out cows closely resembled those of the non-lactating cows.

Non-parturient cows, not milked out before inflation.

The Inorganic and Total Acid Soluble Phosphates were similar. They showed initial increases for fifteen minutes, after which they remained constant until four hours after inflation, when further increases took place. The increases were significant. The Lipid Phosphate showed the same depression as was observed in the above two groups, but the drop was rather reduced (0.91 mgm. %). Because of this, the Total Phosphate fell until four hours after inflation, although like the Inorganic and Total Acid Soluble Phosphates it increased for the first fifteen minutes. From four until ten hours after inflation, the level increased until it was the same as that observed at thirty minutes after inflation. These Total Phosphate changes were not significant.

Table 17. Calcium/Phosphate Changes in Normal Cows after Udder Inflation.
(Means of four non-parturient and six parturient cows.)

Time from Injection.	Calcium/Inorganic P. Non-parturient N.L.	M.O.	N.M.O.	P.	Calcium/Tot.Acid Sol.P. Non-parturient N.L.	M.O.	N.M.O.	P.	Calcium/Total P. Non-parturient N.L.	M.O.	N.M.O.	P.
Before Injection.	1.90	1.94	1.92	17.15	1.80	1.91	1.89	2.89	0.99	0.82	0.80	1.40
After Injection.												
15 m.	1.69	1.83	1.65	2.96	1.58	1.72	1.60	2.17	0.94	0.79	0.77	1.36
30 m.	1.62	1.85	1.58	6.76	1.55	1.74	1.55	2.24	0.80	0.83	0.76	1.35
1 h.	1.48	1.73	1.60	3.30	1.42	1.66	1.58	2.06	0.83	0.81	0.76	1.30
2 h.	1.60	1.70	1.61	4.04	1.51	1.67	1.52	1.93	0.91	0.81	0.77	1.30
4 h.	1.81	1.70	1.58	9.51	1.78	1.66	1.53	1.78	1.04	0.83	0.79	1.19
6 h.	1.84	1.77	1.43	2.48	1.83	1.73	1.39	1.86	1.07	0.88	0.75	1.21
10 h.	1.75	2.01	1.35	3.39	1.70	1.97	1.34	1.63	1.00	0.86	0.72	1.05
Mean.	1.71	1.82	1.59	6.20	1.64	1.76	1.55	2.07	0.96	0.83	0.76	1.27
S.E.	0.074	0.107	0.089	5.065	0.081	0.090	0.085	0.137	0.030	0.017	0.018	0.046
Sig.	5%'	N.S.	5%	N.S.	5%'	N.S.	1%	1%	1%	5%	N.S.	1%

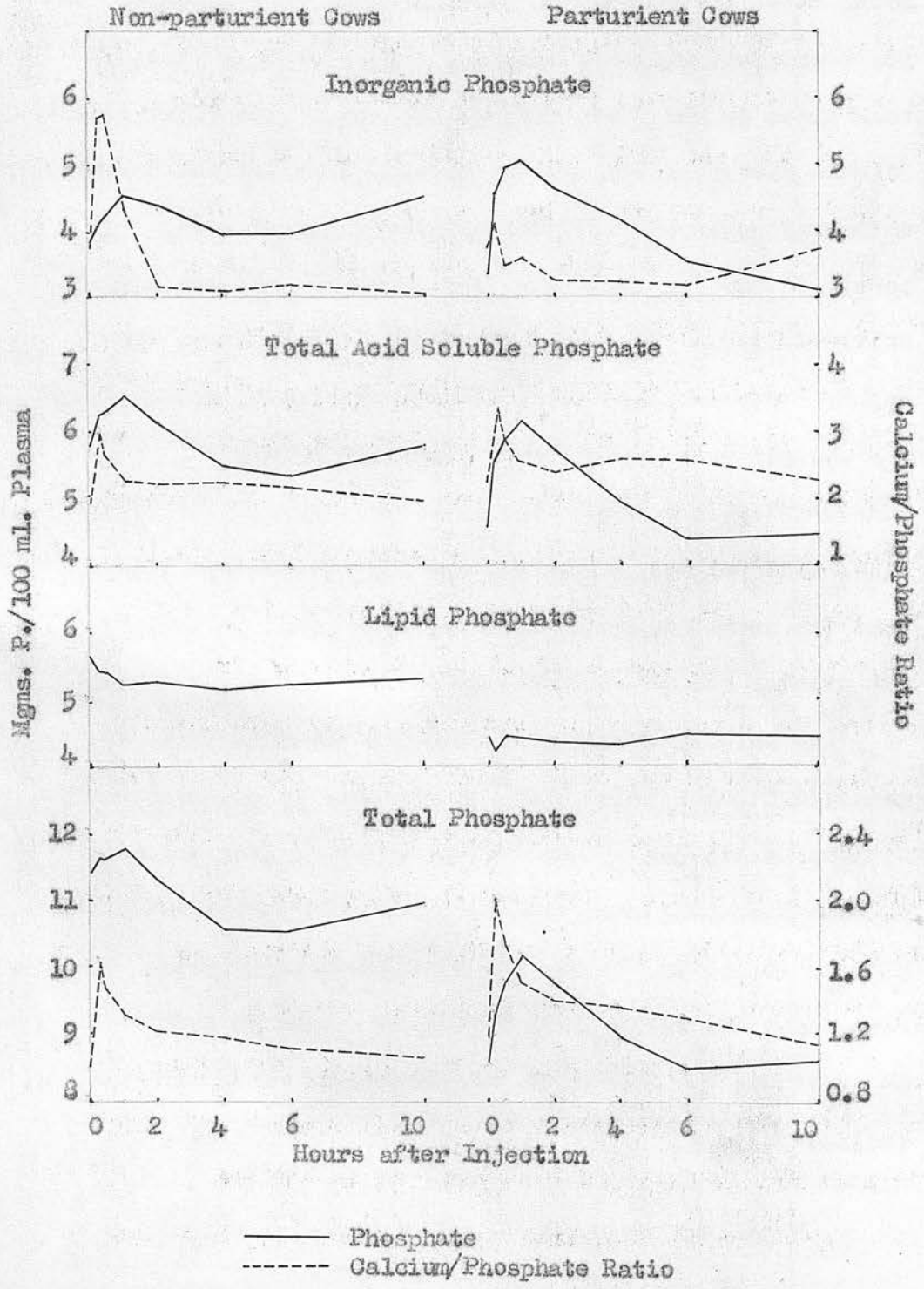
N.L. Non-lactating. M.O. Milked out.
N.M.O. Not milked out. P. Parturient, milked out.

' Two calculated plots, therefore Not Sig. according to Snedecor (90).

Parturient cows, milked out before inflation. The Inorganic Phosphate showed increases in level until six hours after inflation when it started to fall slightly, but its course was slightly erratic. Half of this increase took place in the first fifteen minutes. The Total Acid Soluble Phosphate was similar in some ways but the increase, which was rapid at first and gradually slowed down, continued for the ten hours of observation and was almost uninterrupted. The Lipid Phosphate in this group was rather different from the non-parturient cows, for although the changes were significant, they were small. Consequently, the Total Phosphate was very similar to the Total Acid Soluble Phosphate, the only difference being that the increase after two hours subsequent to inflation was greater for the former than for the latter.

The Calcium/Phosphate ratios are given in Table 17, detailed figures being given in Appendix I, pp. xliii - xlv. With the exception of some values entering into the mean Calcium/Inorganic Phosphate ratios of the parturient cows, all the ratios are within the range for normal cows. In some cases the ratios fell during the whole period of observation, but in others they increased again after an initial fall.

Figure 9. Plasma Phosphates and Calcium/Phosphate Ratios in Normal Cows, injected with Calcium Borogluconate.



(d) Discussion.

Injections of Calcium. In the previous two sections, a case has been made for considering that the Calcium/Total Phosphate ratio is relatively constant and that lowering of plasma phosphate may, therefore, induce a corresponding fall in serum Calcium. Also, in the last section, a suggestion was advanced, based on this Calcium/Total Phosphate ratio, to explain the increase in plasma phosphate which occurred after the injection of Calcium.

It may be noted that the increase in phosphate lasts only for an hour in these normal cows (Figure 9), compared with two hours in milk fever cases giving an Unsatisfactory response and four hours in those giving a Satisfactory response. Despite these time differences, the Calcium/Total Phosphate ratio (1.51) at which the parturient cows show their maximum phosphate increase is markedly similar to that of 1.52 for the milk fever cases (Unsatisfactory response) occurring at the same time after calving (Table 10). The corresponding figure of 1.31 for the non-parturient group is similar to the suggested normal maximum ratio of 1.36 which was given earlier.

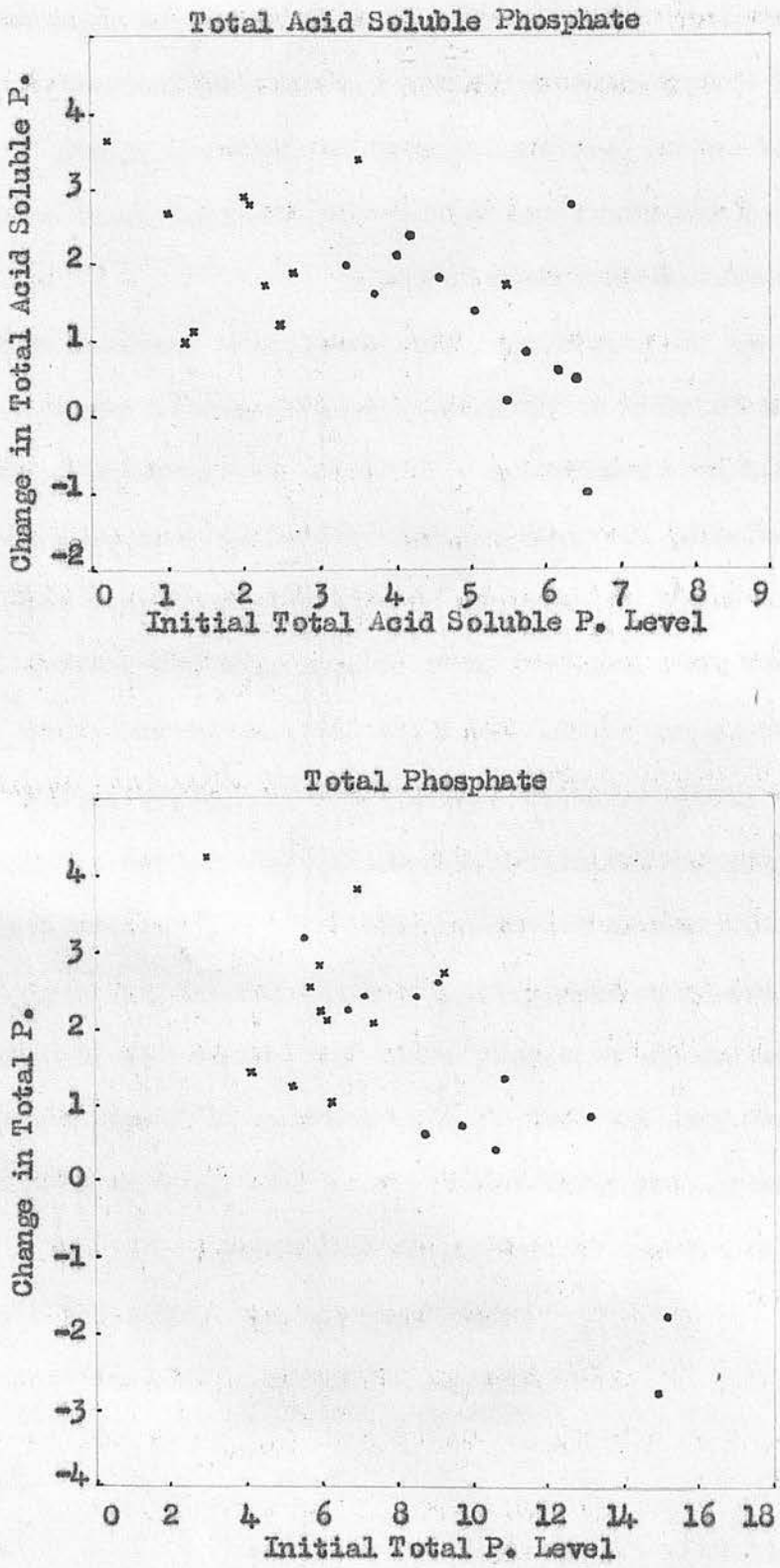
The Calcium/Total Acid Soluble Phosphate ratios at one hour after treatment were also not greater than the highest levels obtained for normal cows, but the Calcium/Inorganic Phosphate ratios have values that are

above normal. These observations support the idea that there is a very wide range for the Calcium/Inorganic Phosphate ratio, but do not help in deciding which, if either, of the other two ratios are involved in determining the Calcium and Phosphate levels.

It may be argued that the phosphates increase until the serum Calcium returns to a certain level, but this can easily be discounted. When the phosphates are at their maximum, the mean Calcium values in this section are 15.25 and 14.80 in the case of the non-parturient and parturient cows respectively, but in milk fever cases the values are much lower, viz. 6.41 for the Satisfactory response group and 8.91 for the Unsatisfactory group. Another suggestion might be that the phosphates increase until their normal values are reached, or, failing that, until a specific level, e.g. a renal threshold, is reached. This also can be rejected, since the values for the milk fever cows and the cows in this section at their highest phosphate values after injection of Calcium Borogluconate show considerable variation, as follows:-

	Milk Fever Cases.		This Section.	
	Satis-factory.	Unsatis-factory.	Non-part-urient.	Part-urient.
Inorganic P.....	3.59	2.25	4.54	5.03
Tot. Acid Sol. P....	3.18	2.96	6.51	6.12
Total P.....	6.55	6.66	11.78	10.15

Figure 10. Changes in Phosphate in Relation to Initial Levels, after Calcium Borogluconate Injection.



There is yet another piece of evidence that Calcium and Total Phosphate are linked. It was noticed that after the injection of Calcium, a large increase in Total Phosphate occurred when its initial level was low, but that a high initial level was associated with a fall in Total Phosphate. Accordingly, these changes in phosphate have been plotted against their initial levels (Figure 10). It was the peak value of the initial phosphate wave, and not necessarily the highest value during the period of observation, which was used in calculating this change. Similar changes occurred in Total Acid Soluble Phosphate (Appendix I, pp. xxxiii and xxxiv). Owing to their erratic movements, it was impossible to calculate these changes for Inorganic Phosphate.

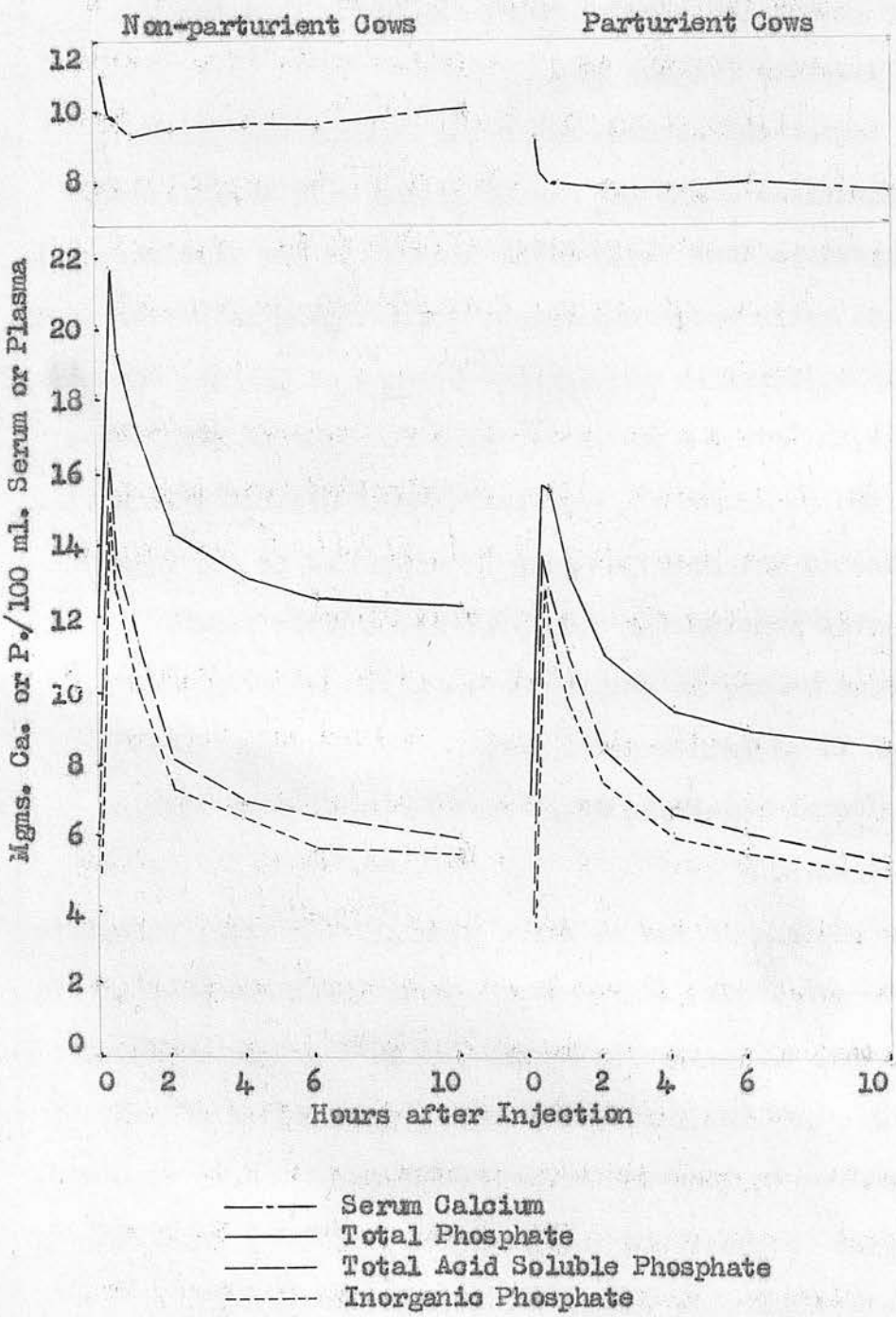
The correlation coefficients for the Total Acid Soluble and Total Phosphate plots are -0.525 and -0.817 respectively, which may indicate a stronger association of Calcium with Total Phosphate than with Total Acid Soluble Phosphate. This correlation was extended to include the milk fever cows, and it was found that those giving a Satisfactory response fitted the regression line, while those giving an Unsatisfactory response showed smaller increases than expected. (Maximum changes marked in Appendix I, pp. xxii and xxiv.) The correlation

coefficient for the experimental injections plus the Satisfactory response group of milk fever cows is -0.513 for the Total Acid Soluble Phosphate and -0.740 for the Total Phosphate (Figure 10).

A connection between the serum Calcium and plasma Total Phosphate would seem to be fairly well established. The suggestion that these are dependent on the Calcium/Total Phosphate ratio being maintained would appear to be the most feasible explanation which takes account of all the changes observed in normal cows at calving, in cases of milk fever and in the experimental animals injected with Calcium salts. Thus, one of the most puzzling observations is the fact that, after Calcium injection, an increase in plasma phosphates occurs in some cases and a decrease in others. This can be explained if it is assumed that the Calcium/Total Phosphate ratio must be maintained within normal limits.

At one end of the scale, a high initial Total Phosphate level is associated with a decrease in Total Phosphate. In such cases, the injection of Calcium in the dose employed does not cause the ratio to increase outwith its normal range and so an increase in phosphate would not be expected. A decrease is possible, however, if a colloidal Calcium Phosphate complex is formed (81), which is rapidly

Figure 11. Plasma Phosphate and Serum Calcium Levels in Normal Cows, injected with Acid Sodium Phosphate.

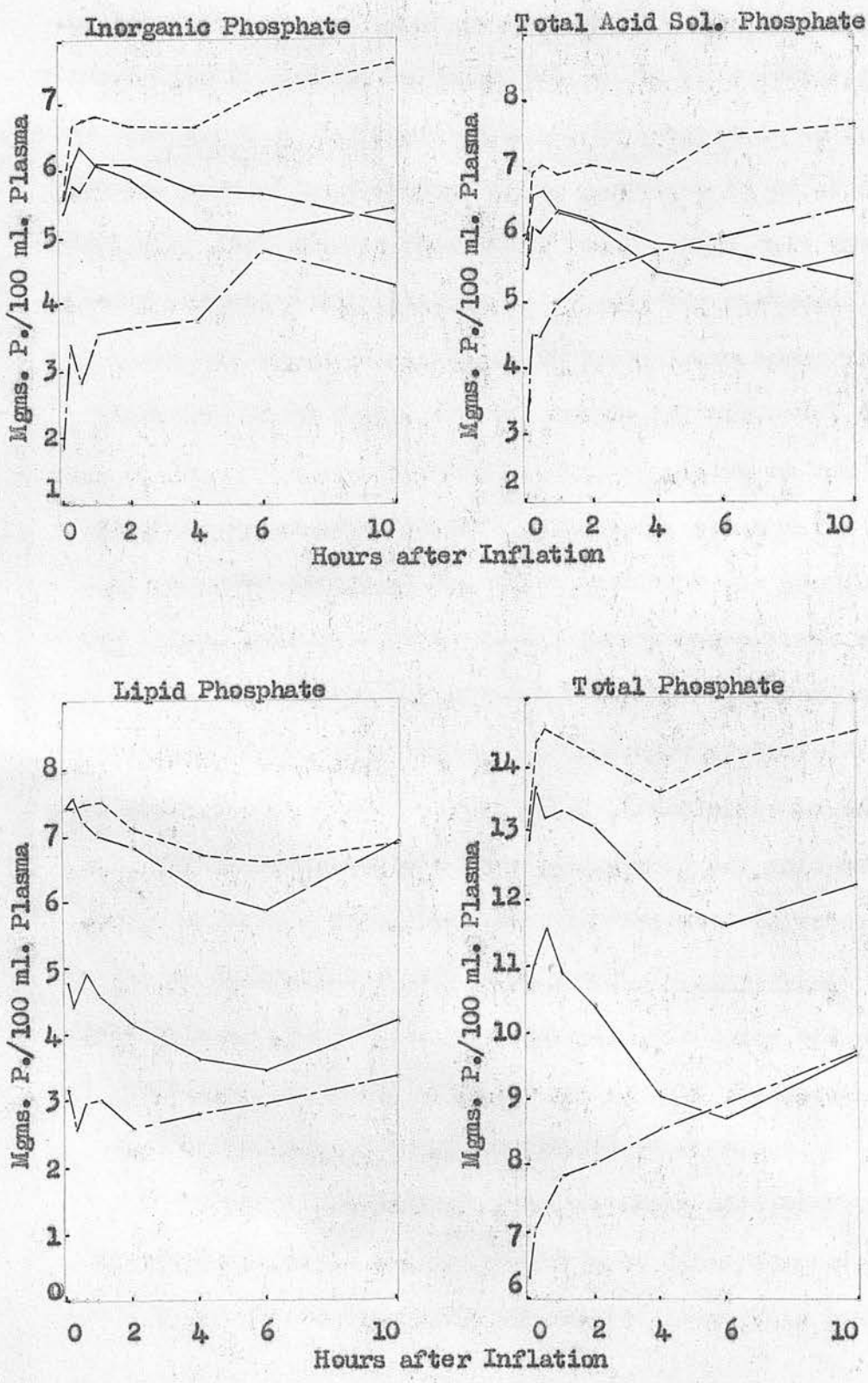


eliminated from the blood, thus depleting plasma phosphate. At the other end of the scale, a low initial Total Phosphate level is associated with a large increase in Total Phosphate; this is to be expected, as an injection of Calcium induces a very high ratio, which takes some time to fall to normal and therefore the phosphate increases for a longer period. Other cases show intermediate changes because the ratio is high for a shorter period and the increases in phosphate are not so great.

It has been pointed out that the increases in Total Phosphate after Calcium injection in normal cows and in milk fever cases which respond Satisfactorily, follow the same pattern. The milk fever cases giving an Unsatisfactory response do not show such great increases as would be anticipated, which may be because the factors depressing the plasma phosphate are too great to be overcome by increasing the Calcium/Total Phosphate ratio.

Injections of Phosphate. These injections do not show the point that it was hoped they would, namely, that by increasing the plasma phosphate levels in parturient cows at a time when we suspect the low phosphates to be depressing the serum Calcium, an increase in this constituent would result (Figure 11). Nor is there any marked difference between the decreases in phosphate level

Figure 12. Plasma Phosphate Levels in Normal Cows after Udder Inflation.



of parturient and non-parturient cows after the injection, which would indicate a difference in the demand for, or excretion of, plasma phosphate. Instead, by these injections, depressions of serum Calcium took place in all cases. A reason for this fall may be that following an injection of phosphate in large amounts, a colloidal Calcium Phosphate complex is formed, which rapidly disappears from the blood (81).

These observations therefore suggest that a large dose of phosphate given alone to a cow with parturient paresis is not desirable; even if injected with Calcium, the one will tend to neutralise the effect of the other.

Udder Inflations.

Reabsorption of phosphate from the milk. Some indication of whether or not reabsorption of phosphate from the milk may take place as a result of udder inflation can be obtained from the three groups of non-parturient cows (Figure 12). This reveals that the Total Phosphate increases for about thirty minutes in all the groups, due to increases in Total Acid Soluble Phosphate and since this increase occurs in the non-lactating cows, factors other than reabsorption may be the cause. The Total Phosphate then declines for about six hours, due largely to a fall in Lipid Phosphate, although the Total Acid

Soluble Phosphate may also be falling. The magnitude of the decline in Total Phosphate is apparently less in the cows that were not milked out than in the other two groups of non-parturient cows, but the difference is not great. There is only one piece of flimsy evidence that reabsorption may occur: the cows that were not milked out did not show any drop in Inorganic or Total Acid Soluble Phosphate after the initial increase at thirty minutes, while the other two groups showed a steady decline for several hours.

Effect on parturient and non-parturient cows. There are marked differences in the responses of parturient and non-parturient cows to udder inflation. Both these groups show an initial increase in Total Phosphate for about thirty minutes, but this is followed by a continuous increase in the phosphate of the parturient cows, which is quite different from the changes in the non-parturient cows. A part of this difference can be attributed to the Lipid Phosphate, which does not alter in the former, but which falls in the non-parturient animals. The rest of the difference is due to the Total Acid Soluble Phosphate; in the parturient cows it shows a steady increase for the duration of the experiment, compared with a fairly constant or declining level in the non-parturient cows. Another group of parturient cows (i.e. those treated for milk

fever - Figure 8) have very similar responses to the parturient cows shown here. It would appear, therefore, that the parturient and non-parturient cows respond differently to udder inflation, but the cause of this difference would seem to be obscure.

Earlier in this paper, evidence was presented that the Total Phosphate may regulate the level of serum Calcium and and the blood changes here conform to this theory. In general, the Calcium and Total Phosphate follow the same course, but the increases in phosphate occur rather more rapidly, as the Calcium/Total Phosphate ratios tend to fall.

(e) Summary.

1. Four ounces of Calcium Borogluconate were injected intravenously into each of six parturient and six non-parturient cows. In both groups, an increase in Inorganic, Total Acid Soluble and Total Phosphates took place, the increases being greater in the parturient cows. There was a negative correlation of -0.817 between the initial level of Total Phosphate and its maximum change attributable to the Calcium injection. Lipid Phosphate showed no change.

2. These effects on phosphate are discussed and the mechanism regulating the Calcium/Total Phosphate ratio suggested as being the cause of the observed changes.

3. Six parturient and six non-parturient cows were given two ounces of Acid Sodium Phosphate intravenously. In all cases the serum Calcium was depressed. The Inorganic, Total Acid Soluble and Total Phosphates rose 9-10 mgm. % fifteen minutes after injection and returned to normal in ten hours, but the Lipid Phosphate tended to drop.

4. The udders of twelve non-parturient cows and six parturient cows were inflated. The plasma Inorganic, Total Acid Soluble and Total Phosphates showed an initial increase in all groups. This was followed by a depression in Total Phosphate in the non-parturient cows, which was greater in the dry cows and those milked out than in those not milked out. The depression was due mainly to a fall in Lipid Phosphate. After this there was a slight rise in Total Phosphate level. The parturient cows showed a continuous rise in this fraction with no depression, which was due to the Lipid Phosphate remaining constant combined with a continuous increase in Total Acid Soluble Phosphate. These changes are discussed.

SECTION IV. SOME AETIOLOGICAL ASPECTS OF PARTURIENT HYPOPHOSPHATAEMIA.

(a) Introduction.

In consequence of the observations that the serum Calcium levels fall at parturition and are low in cases of parturient paresis, it was natural that the cause of these changes should be investigated. Only in latter years have the levels of phosphate been considered, and consequently little has been said about this fraction.

The first point to be determined is whether the fall in phosphate level is due to loss of the ions from the blood, or due to haemodilution. Although there have apparently been no determinations of the blood volume in the bovine at parturition, indirect evidence was brought forward by Wilson and Hart (94), who found that the blood protein rose slightly in four cows and fell in four others. Further, if it were simply a question of haemodilution, all the blood constituents would be expected to maintain the same relative proportions, which is not the case. The serum Calcium and Magnesium move in opposite directions at calving (3, 34, 52) and our own observations showed a big increase in the Calcium/Inorganic Phosphate ratios at calving. It is also apparent that the Total Acid Soluble Phosphate showed a relatively greater fall in level than the Lipid Phosphate. Accordingly, one can dismiss

haemodilution as a major factor in causing the changes in blood phosphate levels.

There are two main factors which may cause a fall in any blood constituent - decreased replenishment or increased excretion or secretion. In both cases very little work has been recorded on blood phosphates, but the methods of investigation are the same as those used for serum Calcium. Of the two alternatives, Van der Meulen (91, 92) has advocated the former, saying that there is an increased demand for Calcium by the blood; because of this a hypocalcaemia develops in older cattle, as the bone reserves are depleted and the intestines cannot make up the deficiency. Hibbs (52, 54) also considers the main cause to be a lack of mobilisation of Calcium, as he could show no difference in the volume or composition of colostrum from milk fever cows and normal cows, at the first and second milkings after calving.

More work has been directed to the secretion and excretion aspect of the blood constituents. With the onset of milk secretion coinciding with the fall in blood levels, it was natural that this should receive most attention. Following their demonstration of a lowered blood Calcium in cases of milk fever, Little and Wright calculated that half a gallon of milk contains sufficient calcium to deplete the blood of a cow of all its calcium, in the absence of any

replenishment (63). The "drainage" theory, as this is known, was also upheld by Dryerre and Greig (24) and later Hallgren (44) stated that the fall in blood calcium coincided with the time when the arterio-venous difference in Calcium level of blood drawn from the carotid artery and the mammary vein became discernible.

Another approach to this subject is by artificially changing the milk output at the onset of lactation. Neidermeier and Smith (68) took blood samples from four cows which were not milked until several days after parturition. They observed a drop in Calcium level at calving and recovery to normal in two days; one of these cows developed milk fever. These observations, however, do not rule out drainage, as the udders of the cows would presumably be distended with secreted milk. Also about the same time Smith, Neidermeier and Hansem (89) studied the effect on the serum Calcium of milking out cows partially and completely. They detected no difference in serum Calcium between the groups, but recorded a higher incidence of milk fever in the partially milked out group.

A third approach is by attempting to separate the onset of lactation from parturition. Smith and Blosser (87) milked cows pre-partum and found that the incidence of milk fever did not alter. Johnson et al (56) also milked cows pre-partum, but could detect no difference

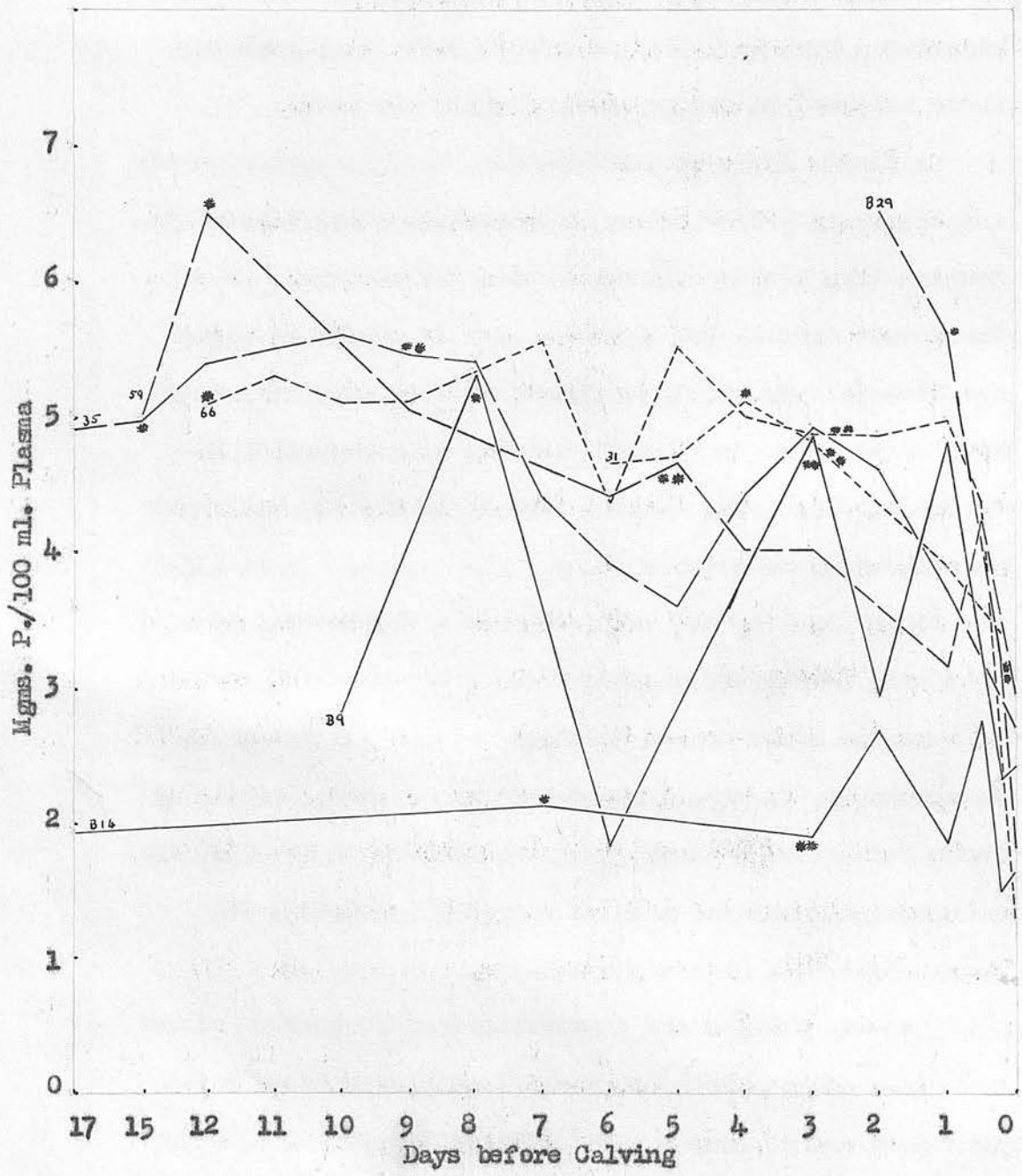
between the serum Calcium and Inorganic Phosphate levels of these cows and those that were milked normally. They recorded a drop in the blood constituents until calving; these returned to normal levels within one week.

A fourth approach has been used by Neidermeier, Smith and Whitehair (70) when they mastectomised eight cows and sampled them through the succeeding parturition. They found that despite the impossibility of phosphate being secreted into the milk, decreases in Inorganic Phosphate took place which were comparable to those occurring in normal calving cows. Serum Calcium levels did not alter significantly from their pre-calving levels. A similar experiment to this had previously been carried out on a goat with comparable results (94).

Of the other routes of blood Calcium and phosphate loss, namely, kidney, large intestine and bone, little is known beyond the observation by Blosser and Smith (14) that at normal calving there is no increase in Calcium and phosphate excretion via the kidneys.

In this section the observations on pre-partum milked cows have been extended to include all the phosphate fractions and to give a more detailed comparison with the results obtained in the previous sections. Moreover, some of the cows selected were animals which were thought likely to develop milk fever, in the hope of obtaining a comparison

Figure 13. Plasma Inorganic Phosphate Levels before Parturition in Pre-partum Milked Cows.



——— Cows at 2nd Calving
———— Cows at 3rd - 6th Calving
------ Cows which developed Milk Fever
* & ** See text.

between milk fever and normal cases. The observations of Neidermeier, Smith and Whitehair with respect to serum Calcium and Inorganic Phosphate were verified on one cow and the other phosphate fractions again estimated.

(b) Materials and Methods.

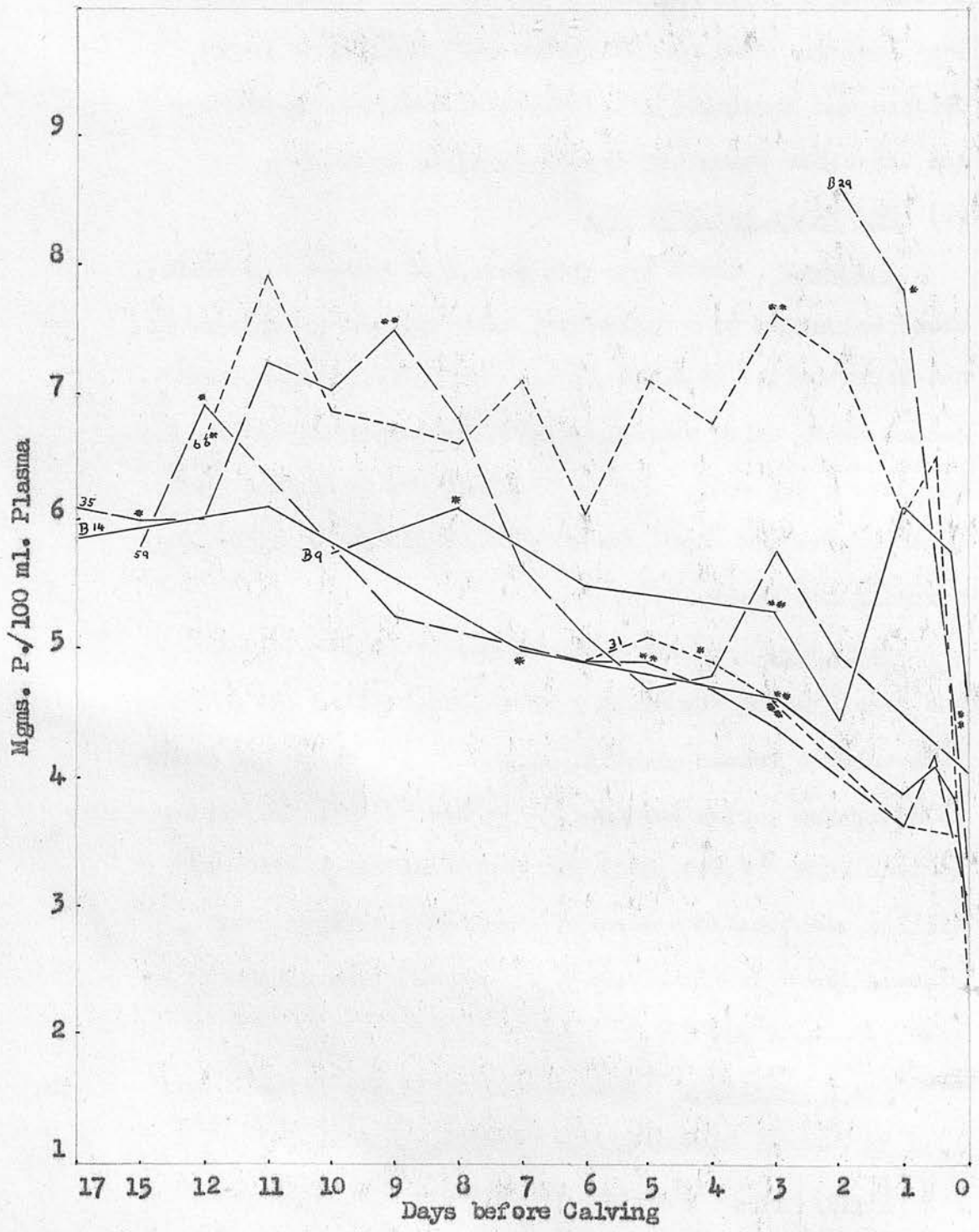
Animals. Seven Ayrshire cows were pre-partum milked, three belonging to a commercial herd and the other four to the Department's Field Station. Two were carrying their second calf, while the other five were carrying their third to sixth calf. Of the latter, two developed milk fever. The cow which was mastectomised was an Ayrshire carrying her fourth calf.

Sampling. In the early stages of pre-partum milking, the total "milk" output of a period was bulked and sampled. When volumes became greater, aliquots were taken and bulked to cover the period required. As far as possible, daily periods were adopted until the day of calving, when each milking constituted a period; the daily periods were resumed two days after calving. Results are expressed as rate of output per day.

Blood Sampling. This conformed to the pattern laid down in General Materials and Methods, page 6.

Mastectomy. This was carried out six weeks prior to parturition, the operation being performed under chloral hydrate anaesthesia.

Figure 14. Plasma Total Acid Soluble Phosphate Levels before Parturition in Pre-partum Milked Cows.



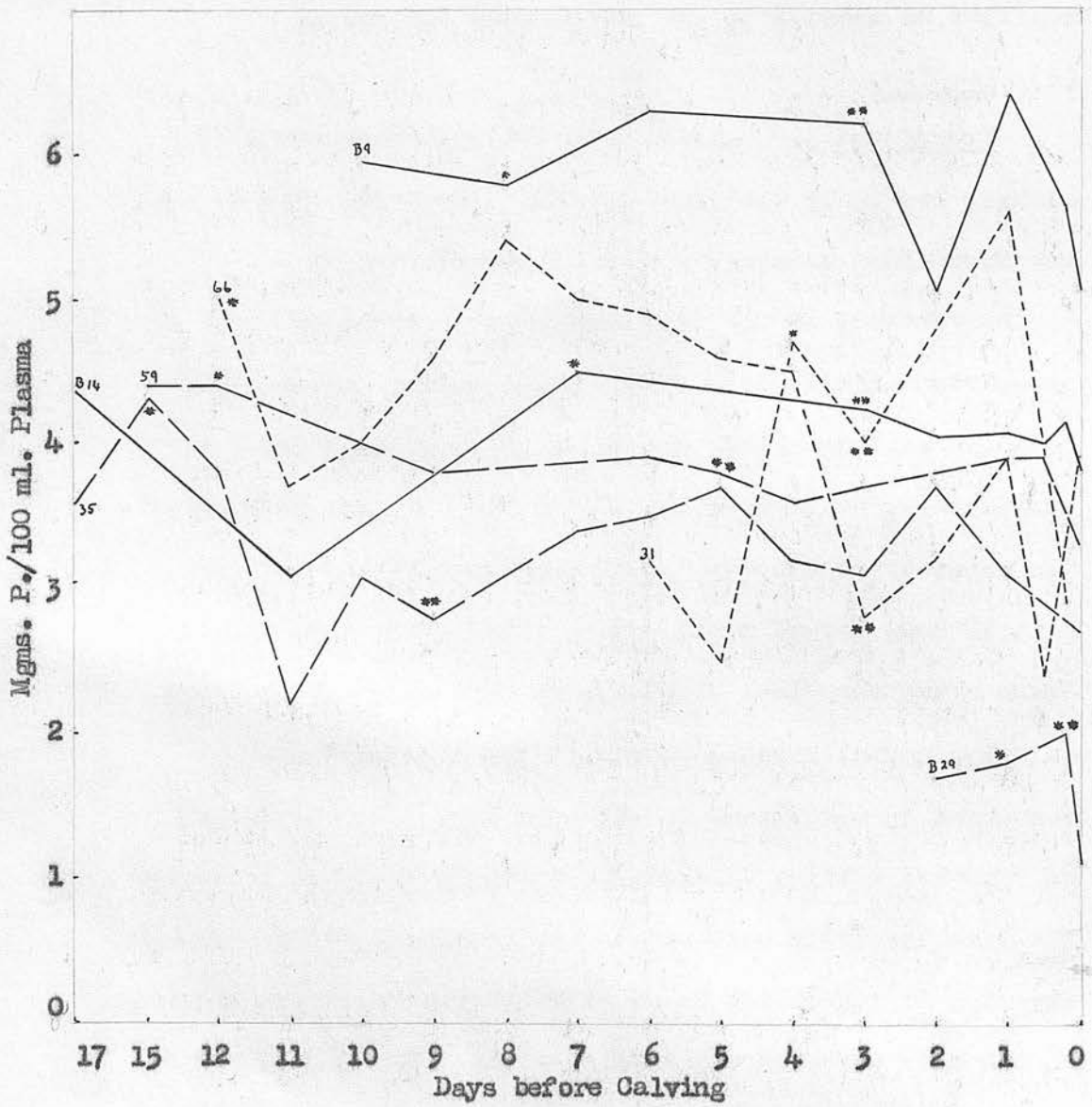
Methods of Analysis. Blood phosphates were estimated as described earlier (page 6). Milk phosphate was determined by the micro method of Graham and Kay (36) modified to conform to the method used for blood.

(c) Results.

Experiment 1. In order to obtain a wide range of milking levels by the time the cows calved and also to avoid any fortuitous changes in blood phosphates being misinterpreted, it was felt desirable to commence pre-partum milking at varying stages before parturition. Thus the milking of cow B14 was started 37 days prior to parturition, while with cow B29 it was only two days before. The onset of milking the other cows was distributed over 6 to 18 days before parturition. The teats were first drawn after the first blood sample was taken and repeated at every normal milking period. "Steaming-up" was commenced in moderation on the same day. In the Tables on pp. xlvi - xlix, Appendix I, a single asterisk indicates the time the first milk sample was obtained, while a double asterisk indicates the point at which the phosphate secreted in the milk exceeded one gram per day. It will be noticed that a secretion could not be drawn from all the cows on the first day and cow B14 was exceptional in that it was four weeks before she yielded more than a few drops of fluid.

Because of the variable onset of sampling, these results do not lend themselves readily to statistical

Figure 15. Plasma Lipid Phosphate Levels
in Pre-partum Milked Cows.



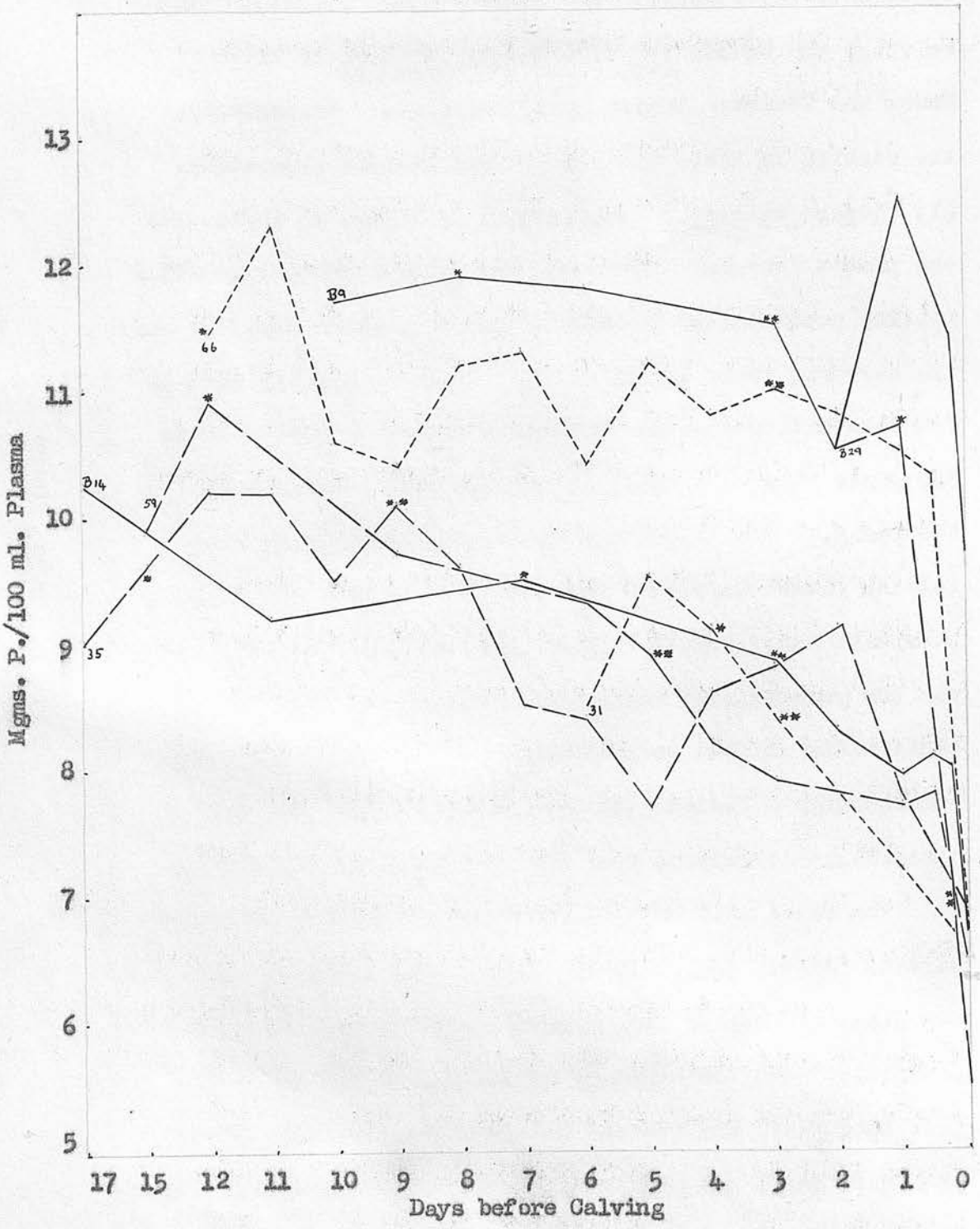
——— Cows at 2nd Calving
— — — Cows at 3rd - 6th Calving
------ Cows which developed Milk Fever
* & ** See text

treatment, especially in the period before calving. After calving, the trends are sufficiently similar to allow Means and Standard Errors to be computed. Accordingly, the results in these two periods are treated separately.

(1) Before Calving. Examination of Figure 13 shows that the plasma Inorganic Phosphate can be very variable. This applies particularly to cows B9 and B14, which were the only two carrying their second calf. It is reasonably certain from the data presented that there was no gradual fall in Inorganic Phosphate level commencing with the onset of secretion. The older cows did have a tendency to show falling plasma Inorganic Phosphate values when the milk phosphate was secreted at more than one gram per day, but the two younger cows neutralised this effect when considering all the cows together. The cows which were subsequently affected with milk fever did not show any appreciable difference from the rest of their age group.

The Total Acid Soluble Phosphate shows more consistent results (Figure 14). It is evident that although there was not always a drop in plasma Total Acid Soluble Phosphate associated with the onset of secretion, by the time the phosphate yield had reached one gram per day, this plasma phosphate level was either falling or about to fall. There would not appear to be any difference between the normal cows and those which developed milk fever. Cow 31 was

Figure 16. Plasma Total Phosphate Levels before Parturition in Pre-partum Milked Cows.



——— Cows at 2nd Calving
——— Cows at 3rd - 6th Calving
------- Cows which developed Milk Fever
* & ** See text

very similar to many of the others and cow 66, although having higher phosphate levels, yielded very little milk over the period.

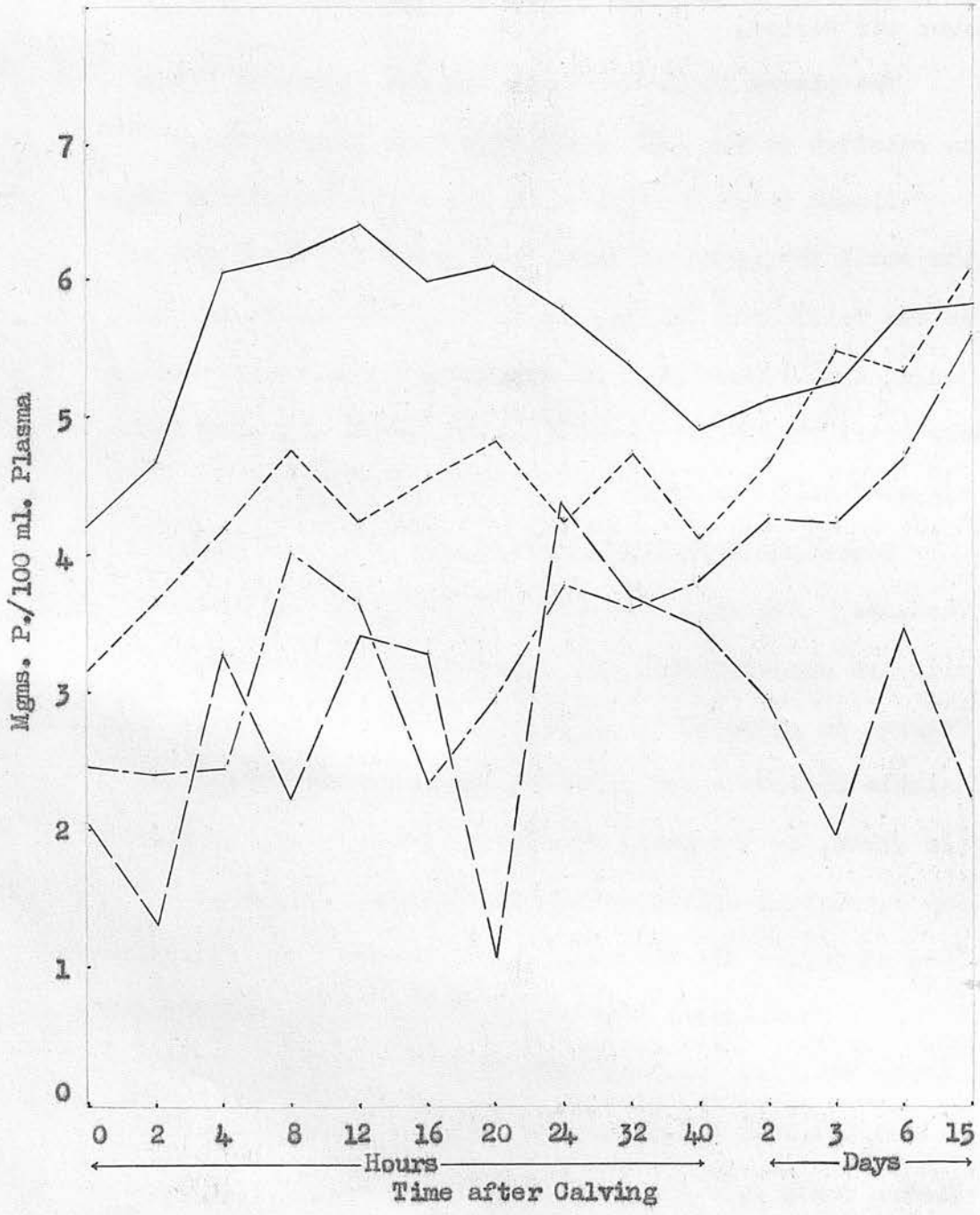
The plasma Lipid Phosphate did not appear to alter in relation to the milk Total Phosphate (Figure 15).

Plasma Total Phosphate, as one would anticipate from the small movements of Lipid Phosphate, was very similar to the Total Acid Soluble Phosphate. As far as can be judged from Figure 16, the only notable difference was in the Total Phosphate level of cow B9, which was very high compared with cow B14.

Correlation Coefficients between Blood and Milk Changes: The milk secretion and Total Phosphate in the milk are compared with the appropriate blood analysis figures in Appendix I, pp. 1 - li. Only Total Acid Soluble Phosphate and Total Plasma Phosphate values are given, as the other fractions do not appear to have any consistent relationship to milk Total Phosphate (see above). The correlation coefficients are as follows:-

Correlation between	r_{xy}	Significance
Plasma Tot.Acid Sol.P. & Milk Yield...	-0.592	1%
Plasma Tot.Acid Sol.P. & Milk Total P.	-0.563	1%
Plasma Total P. & Milk Yield...	-0.179	N.S.
Plasma Total P. & Milk Total P.	-0.173	N.S.

Figure 17. Plasma Inorganic Phosphate Levels after Parturition in Normal and Pre-partum Milked Cows.

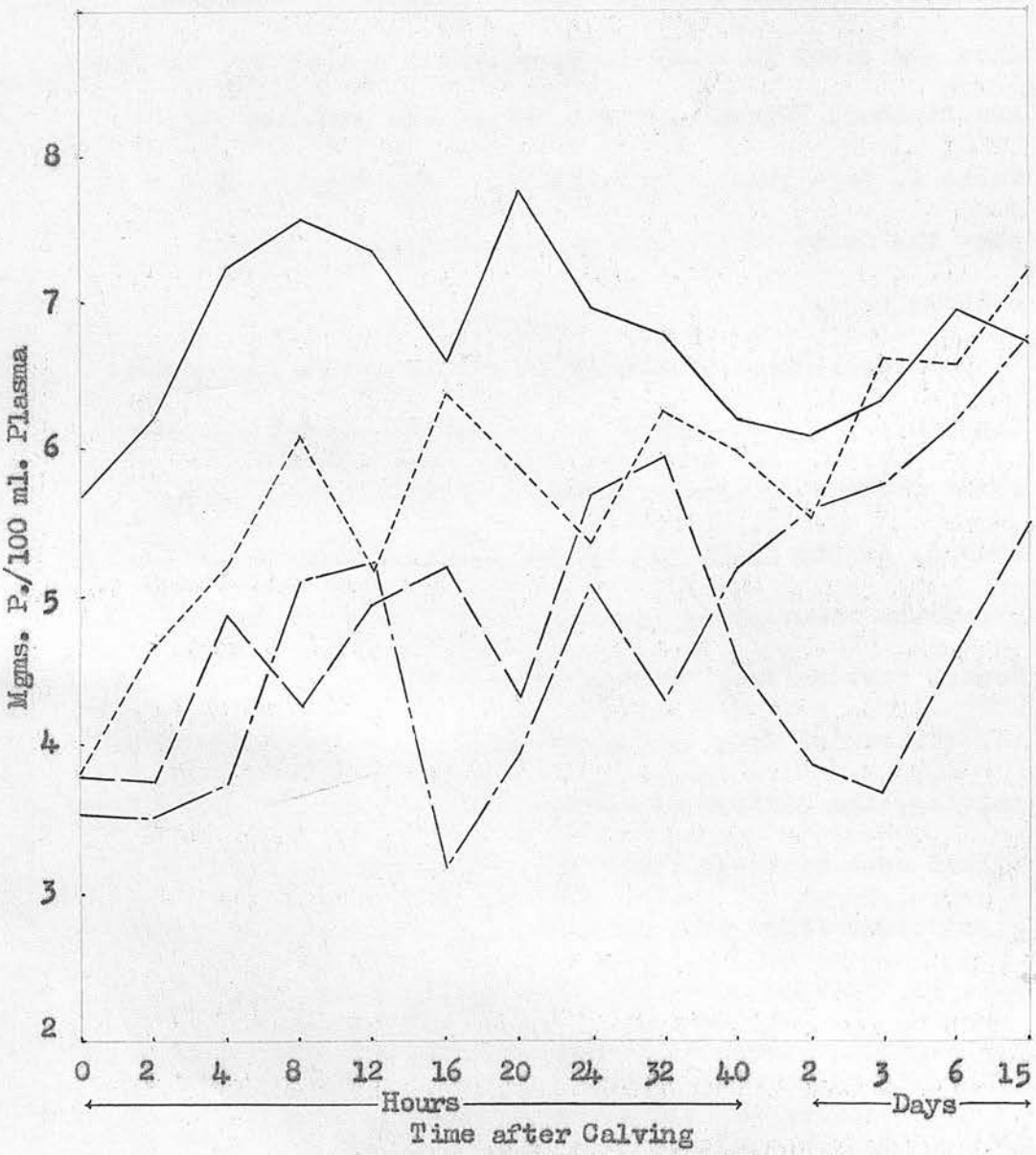


(2) After Calving (excluding milk fever cases). As already pointed out, the values obtained after calving are more amenable to statistical treatment. Original data are given in Appendix I, pp. xlvi - xlix and the Means and Standard Errors of these values are recorded in Table f, page lviii, Appendix II. Figures 17, 18 and 19 show the means of pre-partum milked cows and normal calving cows.

Inspection of Figure 17 reveals that the Inorganic Phosphates of both groups of pre-partum milked cows had lower means than either group of normal calving cows. Indeed, in the first and second calving group where the phosphate recovery is normally rapid, very low values were found, particularly towards the end of the series. Except for the period from thirty-two to forty-eight hours after calving, the differences between the normal and pre-partum milked cows at their first and second calving were significant throughout the series. The third to sixth calving, pre-partum milked cows differed from the corresponding group of normal cows at only two points, the significance of the difference being 5%.

The findings for the Total Acid Soluble Phosphate were similar to those of the Inorganic Phosphate, both groups of pre-partum milked cows following fairly closely the

Figure 18. Plasma Total Acid Soluble Phosphate Levels after Parturition in Normal and Pre-partum Milked Cows.



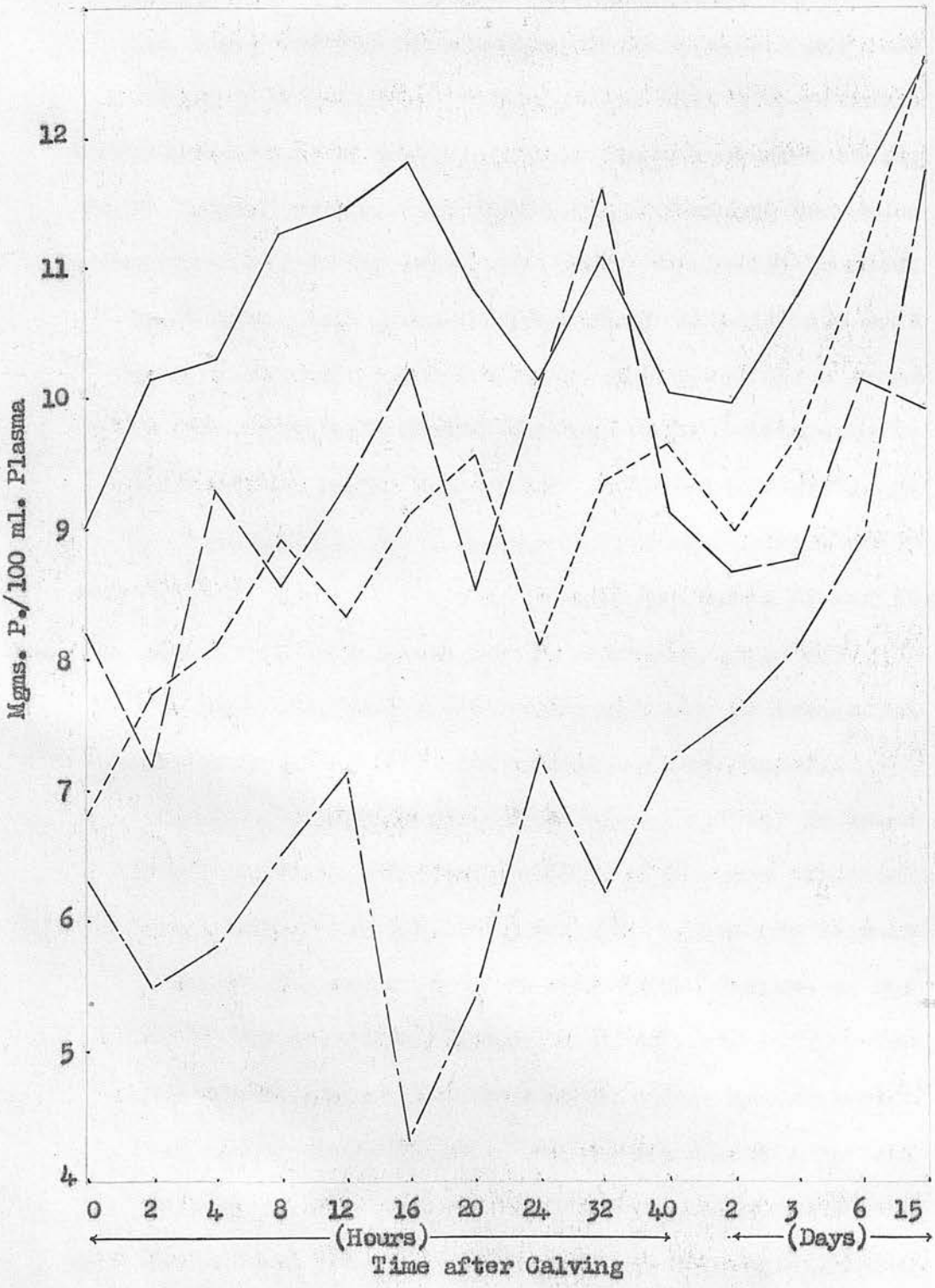
——— Normal Cows at 1st and 2nd Calving
------- Normal Cows at 3rd - 6th Calving
— — — Pre-partum Milked Cows at 2nd Calving
—·— Pre-partum Milked Cows at 3rd - 6th Calving

Statistical analysis of the differences (t test) indicates that the second calving pre-partum milked cows differed significantly from the corresponding normal cows at all points from four hours onwards, except at sixteen-to-twenty hours and twenty-four-to-forty hours after calving. This group of pre-partum milked cows also differed significantly from the third to sixth normal calving group from forty hours until seven days after calving. The older groups of pre-partum milked cows and normal cows were significantly different at only one point, twenty hours after calving and not at sixteen hours as inspection of Figure 18 would suggest.

The Lipid Phosphate of the pre-partum milked cows did not appear to show any marked deviation from normal.

Although the changes in Total Phosphate resembled those of the Total Acid Soluble Phosphate, the Lipid Phosphate once again affected the level at which these changes occurred. Consequently, the Total Phosphates of the pre-partum milked cows at their first and second calving did not differ significantly from those of the corresponding normal cows, except at ten-to-twenty days. The Total Phosphates of the third to sixth calving, pre-partum milked and normal cows differed at only two points, sixteen-to-twenty-four hours and five-to-seven days after calving (Figure 19).

Figure 19. Plasma Total Phosphates after Parturition in Pre-partum Milked Cows.

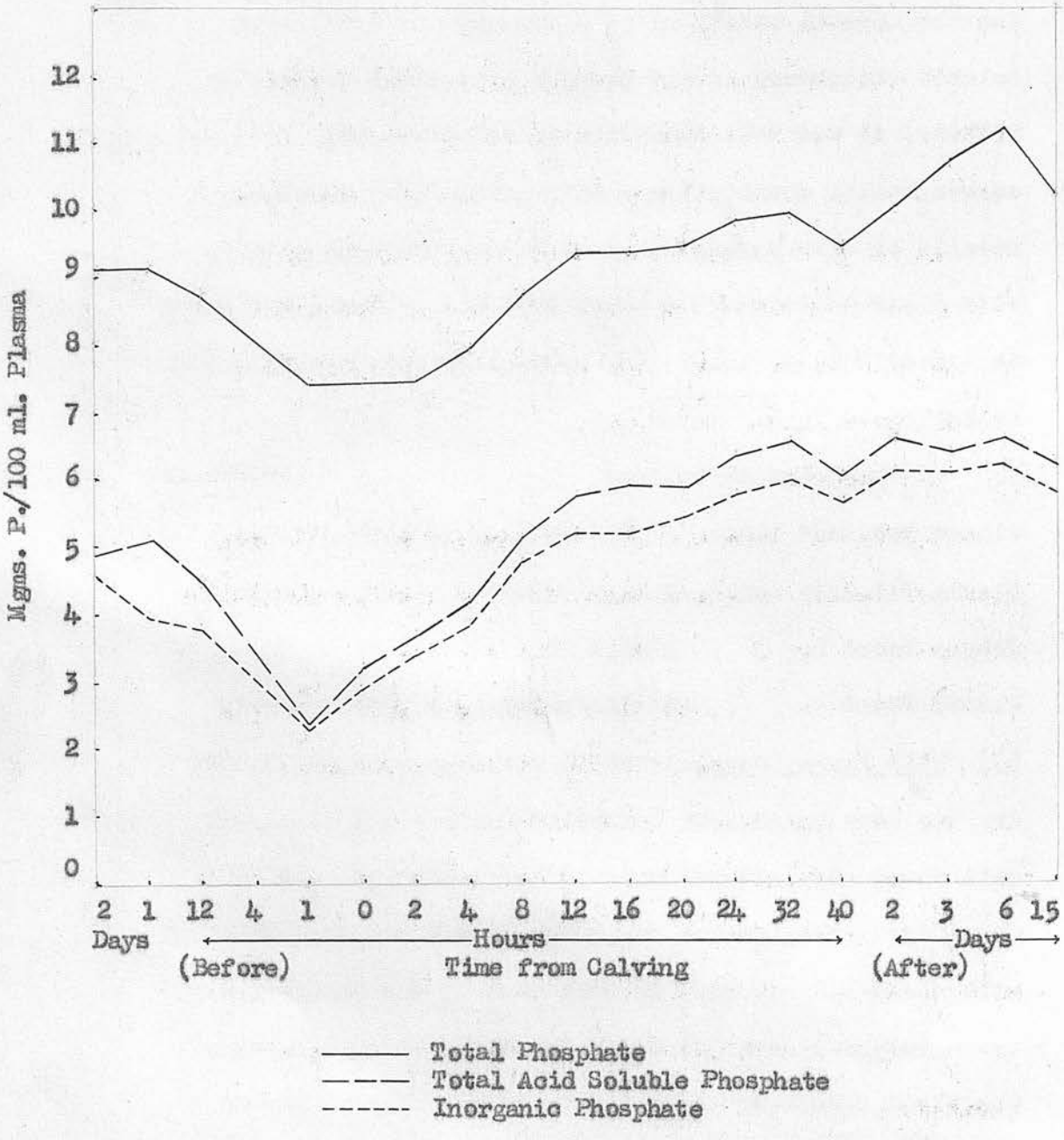


Correlation Coefficients between Blood and Milk Changes: Because of the correlation between blood phosphate levels and milk phosphate yields before calving and the unusual positions of Inorganic and Total Acid Soluble Phosphates in the younger cows after pre-partum milking, it was felt desirable to calculate the corresponding correlation coefficients after calving. Details of milk yields and milk Total Phosphate yields, with their corresponding blood phosphate values, are given in Appendix I, p. lii. The correlation coefficients are as follows:-

Correlation between	r_{xy}	Significance
Plasma Tot.Acid Sol.P. & Milk Yield...	-0.277	N.S.
Plasma Tot.Acid Sol.P. & Milk Total P.	-0.389	5%
Plasma Total P. & Milk Yield...	-0.050	N.S.
Plasma Total P. & Milk Total P.	-0.096	N.S.

(3) Milk Fever Cases. The plasma phosphate levels for the two cows which were pre-partum milked and developed milk fever are included in Section II, so will not be considered here, except for a comparison between blood and milk changes. It will be seen that at the points where these two cows were affected with milk fever, i.e. when the blood phosphates were very low, the milk yield and milk Total Phosphate yields were also very low (Appendix I, p. lii).

Figure 20. Plasma Phosphate Levels in a Mastectomised Parturient Cow.



Experiment 2. Only one cow, at her fourth calving, has been mastectomised so far and blood analyses together with Calcium/Total Phosphate ratios are given in Table g, page lix, Appendix II.

It will be seen that the Inorganic, Total Acid Soluble and Total Phosphates fell until calving, when an increase took place (Figure 20). None of these changes were significantly different from those occurring in normal calving cows of the same age group (Section I). The Lipid Phosphate was also typical of the changes occurring at normal calving.

(d) Discussion.

There are three main factors associated with the onset of lactation which might account for the phosphate changes observed at calving. These are:-

(1) The onset of secretion of phosphate into the milk which may cause a loss of blood phosphate for which the body cannot immediately compensate.

(2) Nerve reflexes from the udder which may upset phosphate metabolism, possibly through the medium of hormones.

(3) Hormones which may be associated with initiating lactation.

(1) In our experiments with pre-partum milked cows, as the yield increases, the plasma Total Acid Soluble and

Total Phosphates gradually fall. The Total Acid Soluble Phosphate falls by 1.65 mgm. % for the two cows at their first and second calving, compared with 2.12 mgm. % for normal cows of the same age group. In the older cows, the fall is 3.5 mgm. % compared with 3.01 mgm. % for normal cows. It will therefore be seen that there is no change in the amount of Total Acid Soluble Phosphate lost by the plasma. On the other hand, the phosphate yields on the milkings at calving average 19.26 and 13.76 gms. for the cows at their first and second, and third to sixth calving respectively. The calculated amount of phosphate obtained from the first milking of normal cows at calving is about 9 gms., so these increased yields of milk phosphate are not associated with increased falls in plasma phosphate levels. Conversely, in the two cows which developed milk fever, the phosphate yields are 17.0 and 14.4 gms. per day at calving and only 10.21 and 5.19 gms. per day at the time of milk fever, when the plasma levels are at their lowest. Prior to this, the yields were no greater than those obtained from the other pre-partum milked cows. It would seem, therefore, that the quantity of phosphate secreted in the milk is not associated directly with the changes in blood phosphate.

This view is borne out by the observations on the mastectomised cow (Figure 20), which confirm the findings

of Neidermeier et al (70). Here, the blood phosphate changes are those one would expect to find in a normal calving cow of the same age, yet secretion of phosphate into the milk is clearly impossible.

(2) Nerve reflexes from the udder do not make any material difference to this discussion, as it is obvious that in the mastectomised cow, no reflexes can occur to cause the phosphate changes. On the other hand, it is fairly certain that such reflexes may predispose to the conditions causing the changes in the blood; by milking the cows before calving a flow of milk together with a depression of plasma phosphate levels could be induced considerably earlier than in normal calving cows. The mode of action of possible nerve reflexes cannot be stated, but it may be through the agency of hormones.

(3) Hormonal production is known to play a part in initiating lactation (85, 86) and there is considerable evidence to suggest that these hormones may be the cause of the plasma phosphate changes. This evidence includes the following points.

a. In the pre-partum milked cows, the plasma phosphates start to fall much sooner than in normal calving cows. The point at which this change occurs coincides with the point at which the milk yield starts to increase rapidly,

that is, when milk secretion is probably being stimulated by hormones, as before this no amount of physical stimulation is successful in raising the yield (Figures 13, 14 and 16).

b. There are fairly high negative correlations between the plasma Total Acid Soluble Phosphate on the one hand and the milk Total Phosphate and the milk yields (p. 75) on the other. These correlations between the blood and milk could indicate either that the depression in the blood is directly associated with the amount of milk phosphate secreted, or that the hormonal mechanisms stimulating the milk yield, or the yield of phosphate, affects the level of plasma phosphate indirectly. The former of these suggestions has been dismissed, as the same plasma phosphate changes occur in mastectomised cows (see (1) above). With regard to the latter suggestion, the correlation coefficient is approximately the same for the plasma Total Acid Soluble Phosphate compared with the yield of milk Total Phosphate (-0.563), as compared with the total milk yield (-0.592). It is therefore impossible to indicate which, if either, of these factors (total milk yield or milk Total Phosphate) may be associated with hormones acting on blood phosphates.

c. The act of mastectomy will not necessarily interfere with the production of hormones essential for the onset

of lactation.

As the correlation coefficients given on page 78 indicate, there is very little correlation between the blood and milk changes after calving. This is because the body appears to compensate for the factors causing the low level of plasma phosphate and the levels rise, despite the increasing yields of milk and milk Total Phosphate. The time when this compensation takes place may be considered as variable, for on plotting out the scatter diagrams the data for some cows appear to break away from the pre-partum correlation almost immediately, while others lie well within the pre-partum scatter for up to seven days after calving.

It is of interest to note that Neidermeier et al did not detect any marked decrease in serum Calcium at calving in mastectomised cows. This might indicate that the fall in serum Calcium is due to secretion in the milk, but in our mastectomised cow, the Calcium/Total Phosphate ratio never exceeded 1.42. As there are indications that the serum Calcium falls only when this ratio is becoming excessive, an induced depression of Calcium due to the observed fall in Total Phosphate would not be expected. The reason for this ratio not becoming excessive must be attributed to the relatively high level of Lipid Phosphate, as the changes in Total Acid Soluble Phosphate are normal

for cows of that age group.

Pre-partum Milking as a Predisposing Cause of Milk Fever. Whatever may be said about its effect on the calf, there would appear to be little evidence so far that pre-partum milking has any harmful effect on the cow so far as the causation of milk fever is concerned. Indeed, Boutflour (15) goes so far as to say that it is beneficial, in that, if properly carried out, it will actually prevent milk fever, but our own two cases of milk fever do not support his contention.

There is a pointer in our results, however, to a possible danger in pre-partum milking young cows and heifers. We were unfortunate in our experiments to have taken two cows at their second calving which had low initial blood phosphate levels, but the marked deviations of the plasma Total Acid Soluble Phosphates of these cows from normal values should not be overlooked. Indeed, the evidence points to pre-partum milking as having induced a blood phosphate picture of a third or later calving cow. As older cows are more prone to milk fever and as has been shown earlier, the Total Acid Soluble Phosphate is a major factor in controlling the level of the Total Phosphate and hence possibly the serum Calcium, there would appear to be some risk of inducing milk fever.

(e) Summary.

1. Seven cows have been pre-partum milked and blood and milk phosphate analyses carried out through the period. Two of these cows were carrying their second calf, while the others were carrying their third to sixth calf; of these, two developed milk fever after calving. One further cow was mastectomised, and samples were taken during the ensuing parturition and analysed.

2. In the pre-partum milked cows, the plasma Total Acid Soluble Phosphate before calving gave negative correlations with the milk yield and with the milk Total Phosphate yield, of -0.592 and -0.563 respectively. The correlations were very much reduced after calving.

3. Mastectomy was followed by the same plasma phosphate changes as one would expect to find in a cow calving normally. Serum Calcium levels did not alter, but the Calcium/Total Phosphate ratio never exceeded 1.42.

4. The results are discussed, and it is suggested that the plasma phosphate changes may be due to hormonal influences, and not to drainage into the milk.

5. It is suggested that the Calcium deficiency at calving could be attributed to a drop in plasma Total Phosphate, due to a loss of Total Acid Soluble Phosphate, which in turn could be caused by these hormonal influences.

6. A possible danger that pre-partum milking in young cows may predispose to milk fever is discussed.

D. GENERAL CONCLUSIONS AND SUMMARY.

The depression in serum Calcium levels at calving in normal cows and the low serum Calciums in cases of milk fever are well established. There is little evidence as to the cause of these low levels, but various theories have been advanced from time to time and recently attention has been drawn to the possible involvement of phosphate. It is known that phosphate is associated with ionised Calcium in the blood (8, 9) and there are records that the Inorganic Phosphate and the Ultrafiltrable Calcium Complex are similarly reduced in cases of milk fever (26, 34). More recently the observation was made that the Inorganic Phosphate is low in cases of milk fever which do not respond to treatment, but increases in cases that do respond (72, 73), from which the suggestion has arisen that low blood phosphate may actually depress serum Calcium. The results in Section II confirm these observations; phosphate values which do not increase or which fall after an initial increase are related to cases that do not respond satisfactorily.

Further evidence on this suggested action of phosphate on serum Calcium is given by normal calving cows. Here the plasma phosphate level falls before the serum Calcium level, but the Calcium/Total Phosphate ratio rapidly returns to

normal, regardless of whether the Calcium and Total Phosphate are normal or not.

Apart from the association between ionised Calcium and Inorganic Phosphate, there is so far little indication as to where a connection between Calcium and phosphate may lie. Throughout this work, however, there are indications that the Total Phosphate is linked to the serum Calcium. Evidence of this is shown by the good correlation between the initial Total Phosphate level and its increase after the injection of Calcium salts, by the consistent Calcium/Total Phosphate ratios at all physiological levels of Calcium and Total Phosphate and by the increase in Total Phosphate until this ratio returns to normal after the injection of Calcium Borogluconate.

From a study of these data, the suggestion is made that the relative levels of Calcium and Total Phosphate are dependent on the maintenance of a normal Calcium/Total Phosphate ratio. Thus a decrease in Total Phosphate, as in cows at normal calving or in cases of milk fever, may tend to increase the ratio above its normal maximum, and so induce a depression in serum Calcium level. Similarly, provided the initial phosphate level is not high, the injection of Calcium salts increases the Calcium/Total Phosphate ratio above normal. In this event, it is suggested that not only does the Calcium level fall rapidly,

but the phosphate level increases to aid the return of the ratio to normal. Although the cows which respond Unsatisfactorily to Calcium therapy do not show as great increases in Total Phosphate as the other cows, in all cases the increases continue until the ratio has returned to normal. As far as can be ascertained, it is only the maximum limit which is sharply defined; there is no evidence of a minimum ratio and so an injection of Acid Sodium Phosphate, in the dosage normally used, induces no increase in serum Calcium level.

It would appear, therefore, that the Calcium level is regulated to a certain extent by the Total Phosphate level. This in turn is controlled by its two principal fractions, the Lipid Phosphate and the Total Acid Soluble Phosphate. The Lipid Phosphate does not alter significantly within a few days of calving and consequently does not account for the changes which occur in Total Phosphate in both normal parturient cows and those which develop milk fever. It can, however, influence the level of Total Phosphate, as individual animals tend to have consistently high or low Lipid Phosphate levels, which may induce correspondingly high or low Total Phosphate levels. The changes in Total Phosphate are largely due to alterations in Total Acid Soluble Phosphate, which consists mainly of Inorganic Phosphate; but there are some exceptions as very low

Inorganic Phosphate levels with normal Total Acid Soluble Phosphate levels have been obtained. For this reason, the Total Acid Soluble Phosphate is possibly the better indicator of the blood phosphate changes; moreover, this fraction may be useful in predicting the nature of the response to Calcium therapy in cases of milk fever.

The phosphate levels in cows at normal calving fall, this drop being greater in the cows at their third to sixth calving, than in those at their first and second calving. Even lower levels are obtained in milk fever cases, which agrees with the idea that milk fever is an exaggeration of a normal physiological response, as the incidence of this condition increases with increasing number of parturitions.

The cause of these physiological disturbances is rather obscure, but it has been shown that the changes in Inorganic Phosphate observed in normal cows at calving also occur in mastectomised cows; in the single case recorded here it would appear that the changes in the other phosphate fractions follow the normal course. Accordingly, drainage of phosphate into the milk does not seem to be an essential feature of the low phosphate levels in normal cows, but there is evidence that hormones inducing lactation may be responsible (Section IV).

In conclusion then, it would seem logical that further investigation of the causes of the blood phosphate changes

at parturition should be turned towards their hormonal controlling mechanisms. Of the many hormones that may be involved in phosphate metabolism, it would seem that those concerned with the initiation of lactation are more likely to yield useful results in advancing our knowledge of the aetiology of milk fever.

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APPENDIX I.

Where specified, the following symbols have been used throughout these Appendices:-

All times above C. are before calving; those below C. are after calving.

C. Period from one hour before calving until two hours after calving.

d. days.

h. hours.

' Value shown is the mean of two samples.

" Value shown is the mean of three samples.

Normal Daily Variations in Plasma Phosphates.

Cow No.	Inorganic Phosphate.* Consecutive Days.					Total Acid Soluble Phosphate.* Consecutive Days.				
	1.	2.	3.	4.	5.	1.	2.	3.	4.	5.
B 2.	4.95	4.75	5.75	4.50	4.25	5.40	5.60	6.55	5.00	5.00
B 5.	5.95	6.00	6.05	5.85	6.35	6.70	6.65	7.15	6.95	7.40
B 9.	6.20	6.35	6.15	6.30	6.30	6.70	7.20	6.80	7.35	7.20
B12.	5.20	5.50	5.50	5.45	5.55	5.55	6.80	6.30	6.30	6.25
B19.	5.25	5.35	4.25	5.05	4.75	5.85	6.00	4.90	5.55	4.70
B23.	4.85	3.90	4.20	3.80	4.05	5.40	4.70	4.90	5.00	4.60
B32.	5.55	5.15	5.15	5.90	5.90	6.25	6.10	5.90	6.75	6.40
B33.	5.75	5.35	6.25	5.35	5.50	6.35	5.85	6.80	6.10	6.00
B34.	5.35	4.95	5.40	5.70	6.00	5.75	5.70	5.80	6.35	6.75
Cow No.	Lipid Phosphate.* Consecutive Days.					Total Phosphate.* Consecutive Days.				
	1.	2.	3.	4.	5.	1.	2.	3.	4.	5.
B 2.	9.80	9.90	10.10	10.40	10.20	13.60	15.20	15.40	15.00	15.60
B 5.	5.80	6.00	6.10	5.70	5.60	12.50	12.50	11.70	11.90	11.70
B 9.	11.80	12.10	12.40	12.40	12.90	19.10	19.30	19.40	19.40	19.00
B12.	7.70	7.40	7.90	7.80	7.90	13.80	13.80	13.60	13.80	13.80
B19.	6.90	7.00	7.30	7.30	7.20	12.00	12.60	12.50	12.10	11.90
B23.	8.10	8.60	8.60	8.00	8.40	13.60	13.30	13.00	13.80	13.00
B32.	8.60	8.80	8.20	8.00	8.10	14.20	14.50	14.70	14.10	15.50
B33.	4.90	5.20	5.20	4.60	4.40	11.80	11.10	11.90	11.10	10.90
B34.	5.00	5.70	5.40	5.10	4.60	11.90	12.00	11.00	11.80	11.10

* Mgms. P./100 ml. Plasma.

Inorganic Phosphate Levels in Normal Parturient Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Number of Calving I.						
	No. 2.	No. 8.	No. 9.	No. 12.	No. 17.	No. 57.	No. 67.
14 d.	-	-	6.65	-	-	6.00	6.00
12 d.	-	-	7.65	-	-	6.80	-
11 d.	-	-	-	-	-	5.40	5.70
10 d.	-	-	-	-	3.90	6.25	-
9 d.	-	-	-	-	-	5.60	6.10
8 d.	-	-	6.50	-	5.50	5.95	-
7 d.	-	-	6.80	5.00	-	6.50	5.20
6 d.	-	-	-	5.40	-	5.60	-
5 d.	-	5.35	6.10	5.50	4.60	6.45	5.80
4 d.	-	-	4.20	6.50	-	6.35	-
3 d.	-	7.25	4.00	6.12	6.40	7.00	5.85
2 d.	-	-	4.85	5.20	6.40	5.95	-
1 d.	4.80	-	-	6.05	5.30'	5.40	4.80
12 h.	-	-	6.15	5.20	5.10	5.55'	-
4 h.	-	-	5.50	6.50	-	5.60	4.30
1 h.	3.30	-	6.20	-	-	5.00	3.40
C.	2.70	5.80	-	4.35	4.60	5.50	4.10
2 h.	-	5.05	4.90	-	4.40	-	5.35
4 h.	5.80	-	-	7.25	-	6.95	5.60
8 h.	-	-	6.80	-	-	7.45	-
12 h.	-	8.65	-	7.20	5.70	7.30	5.45
16 h.	-	-	6.25	-	-	6.90	4.75
20 h.	7.50	-	-	-	4.80	6.70	-
24 h.	-	-	-	6.15	-	-	4.65'
32 h.	-	-	6.10	4.35	3.50	5.90	4.85
40 h.	-	-	-	-	-	5.15	3.70
2 d.	-	6.45	-	5.35	-	3.15	4.30"
3- 4 d.	6.00	-	-	-	3.00	3.65	4.95
5- 7 d.	-	-	6.75	5.10	-	5.65	4.40
10-20 d.	5.90	6.10	6.00	6.50	6.00	5.85	5.30

Key to symbols - see page i, Appendix I.

Inorganic Phosphate Levels in Normal Parturient Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Number of Calving II.							
	No. 3.	No. 4.	No. 5.	No. 16.	No. 24.	No. 53.	No. 54.	No. 59.
14 d.	-	-	-	-	-	-	-	6.40
12 d.	-	-	-	5.50	-	7.30	-	6.10
11 d.	-	5.70	-	6.80	-	-	-	6.10
10 d.	-	-	-	-	-	-	-	5.05
9 d.	-	7.00	-	-	-	-	-	5.90
8 d.	-	-	-	5.45	6.10	-	-	-
7 d.	-	6.80	-	-	-	6.00	6.65	5.90
6 d.	-	6.35	-	-	4.90	7.40	-	5.75
5 d.	6.70	7.40	-	4.70	-	5.40	5.85	6.80
4 d.	-	5.40	4.75	5.70	5.40	6.45	4.50	6.65
3 d.	5.20	-	-	6.50	6.20	5.60	5.55	6.60
2 d.	5.30	6.10	6.75	5.90	6.20	6.30	6.35	-
1 d.	-	6.80'	-	5.40	5.25'	6.40	6.25	6.60
12 h.	5.65'	5.60	-	5.20	-	5.30	6.80	-
4 h.	4.15	4.60	-	4.60	-	6.10	-	5.25
1 h.	5.70	3.45	-	-	4.20	4.90	4.85	-
C.	-	3.80	4.50	3.20	2.90'	5.60	4.15	3.40
2 h.	5.00	-	5.05	3.50	-	5.50	-	3.25
4 h.	5.90	6.15	-	-	5.00	6.65	6.15	5.25
8 h.	6.80	-	-	6.00	4.70	7.15	5.65	4.80
12 h.	6.40	-	-	6.50	5.00	-	6.05	5.70
16 h.	-	-	5.85	-	-	6.80	5.40	-
20 h.	-	-	-	-	5.20	6.30	-	-
24 h.	5.90	7.05	-	5.80	-	5.90	-	4.95'
32 h.	-	-	-	6.15	-	6.90	5.90	4.65
40 h.	-	-	-	-	4.90	-	5.85	-
2 d.	4.20	5.85	-	6.20	5.50	5.65'	4.65	4.90'
3- 4 d.	5.00	6.45	5.80	5.00	5.50	6.00	5.05	6.70
5- 7 d.	6.30	-	-	-	-	5.40	6.50	6.10
10-20 d.	5.80	6.55	6.10	6.20	5.60	4.95	4.80	5.70

Key to symbols - see page i, Appendix I.

Inorganic Phosphate Levels in Normal Parturient Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Number of Calving III.								
	No.6.	No.10.	No.11.	No.13.	No.14.	No.15.	No.22.	No.27.	No.55.
14 d.	5.20	-	-	-	-	6.70	-	-	-
12 d.	6.05	4.60	-	-	-	-	-	-	-
11 d.	-	-	5.30	-	-	5.10	-	-	-
10 d.	-	-	-	-	-	6.20	-	-	-
9 d.	-	-	5.85	-	-	-	-	6.00	5.30
8 d.	-	-	5.80	-	-	5.80	-	-	-
7 d.	-	-	5.80'	-	-	4.90	3.50	5.35	5.50
6 d.	-	-	5.75	6.00	7.00	-	-	5.25	5.35
5 d.	-	-	5.50	-	5.90	6.55	6.20	4.55	5.75
4 d.	-	-	5.40	5.50	-	6.30	-	4.80	6.40
3 d.	-	7.15	-	5.70	6.30	6.70	4.50	4.20	6.30
2 d.	5.85	6.20	5.50'	5.00	5.20	6.00	4.80	4.90	6.95
1 d.	-	6.95	5.35	-	-	-	6.20	4.70	6.20
12 h.	-	-	-	5.50	-	6.20	-	4.85	5.40
4 h.	4.15	-	-	-	4.55	-	-	-	4.90
1 h.	3.20	4.25	4.20	3.50	3.80	-	-	-	3.20
C.	-	3.40	3.85	3.60	3.25	3.00	3.50	3.60	3.10
2 h.	3.35	3.65	3.55	3.85	-	3.10	3.80	2.75	3.40
4 h.	4.75	-	5.85	5.25	4.60	4.05	4.90	2.20	5.00
8 h.	3.75	6.40	6.20	-	-	-	5.60	2.90	4.40
12 h.	-	-	-	4.85	-	6.50	-	2.50	4.90
16 h.	3.10	-	5.30	4.90	3.50	-	-	-	4.45
20 h.	-	6.20	-	-	-	-	5.20	5.20	4.10
24 h.	3.00	-	4.40	-	3.10	5.40	4.60	4.30	-
32 h.	-	-	-	-	-	-	-	-	3.50
40 h.	2.85	-	4.45	3.95	3.00	-	-	-	4.00
2 d.	4.35	7.12	5.30'	5.40	3.90	5.70	5.00	4.05'	2.00
3- 4 d.	7.10	-	-	7.00	-	5.80	4.70	4.10'	3.95'
5- 7 d.	-	-	-	-	6.30	-	5.30	3.90	4.45
10-20 d.	7.05	5.00	5.10	6.60	7.30	7.00	7.40	5.70	5.20

Key to symbols - see page i, Appendix I.

Inorganic Phosphate Levels in Normal Parturient Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Number of Calving IV. No.18.	IV. No.19.	IV. No.26.	IV. No.30.	V. No.20.	V. No.23.	VI. No.21.	VI. No.28.
14 d.	-	-	4.60	-	-	-	-	-
12 d.	5.70	-	5.20	-	-	-	-	-
11 d.	-	-	-	-	-	-	-	-
10 d.	-	-	5.80	-	-	-	-	4.90
9 d.	-	-	-	-	6.05	4.70	-	-
8 d.	4.45	-	-	-	-	-	6.35	-
7 d.	-	-	5.90	5.25	-	-	-	-
6 d.	4.75	-	-	-	8.10	4.10	-	5.55'
5 d.	4.60	-	4.60	-	-	-	6.20	-
4 d.	-	-	-	-	8.80	4.40	-	4.55
3 d.	4.15	-	5.25	-	9.40	-	5.80	4.65
2 d.	4.60	3.80	5.15	7.20	6.50	6.70	6.60	4.55
1 d.	4.70'	4.50	-	-	5.50	7.00	5.55	4.80
12 h.	4.60	-	4.50	-	5.30	-	5.30	3.90
4 h.	-	4.20	-	-	-	-	-	-
1 h.	-	-	1.65	-	-	5.70	-	-
C.	3.90	2.60	1.55'	-	2.20	-	4.10	2.40
2 h.	4.30	2.30	-	-	-	5.00	4.90	-
4 h.	3.50	4.10	2.20	2.55	3.70	6.00	5.90	2.30
8 h.	-	-	3.70	2.95	4.60	6.60	6.20	3.75
12 h.	4.00	2.90	3.10	-	4.50	-	4.70	-
16 h.	4.40	3.45	-	4.70	4.70	6.60	4.80	-
20 h.	-	-	3.40	-	5.20	-	-	4.45
24 h.	-	-	-	4.00	-	-	-	5.00
32 h.	4.60	-	4.10	-	5.90	5.70	4.50	-
40 h.	-	5.60	4.80	-	-	-	-	-
2 d.	4.18	4.25	4.50'	-	4.65'	5.30	4.00	-
3- 4 d.	-	6.60	4.60'	-	5.30	5.30	5.60	5.65
5- 7 d.	-	-	5.40'	-	6.00	-	6.20	5.00
10-20 d.	6.80	4.60	4.90	-	-	-	6.20	6.20

Key to symbols - see page i, Appendix I.

Total Acid Soluble Phosphate Levels in Normal Parturient Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Number of Calving I. No.2.	No.8.	No.57.	No.67.	II. No.3.	No.5.	No.24.	No.53.	No.54.	No.59.
14 d.	-	-	7.10	7.30	-	-	-	-	-	7.60
12 d.	-	-	7.75	-	-	-	-	8.60	-	6.90
11 d.	-	-	6.90	6.50	-	-	-	-	-	6.75
10 d.	-	-	7.25	-	-	-	-	-	-	6.50
9 d.	-	-	7.30	7.50	-	-	-	-	-	7.50
8 d.	-	-	6.95	-	-	-	7.70	-	-	-
7 d.	-	-	6.95	5.60	-	-	-	7.10	8.30	6.50
6 d.	-	-	6.60	-	-	-	8.15	8.00	-	6.65
5 d.	-	6.55	7.50	5.85	8.25	-	-	6.45	6.70	7.60
4 d.	-	-	7.50	-	-	5.85	6.60	7.15	5.85	6.90
3 d.	-	7.75	8.15	8.00	8.10	-	8.75	6.65	7.20	6.90
2 d.	-	-	7.20	-	8.15	7.00	8.75	7.60	8.00	-
1 d.	6.25	-	6.60	7.15	-	-	7.43'	7.75	7.25	6.60
12 h.	-	-	6.90'	-	6.85'	-	-	6.75	7.30	-
4 h.	-	-	6.45	5.40	5.20	-	-	7.35	-	5.80
1 h.	3.60	-	5.90	5.90	5.75	-	6.00	6.20	5.55	-
C.	2.85	7.60	6.10	5.05	-	-	4.08'	6.80	4.45	3.60
2 h.	-	5.55	-	7.95	6.55	5.90	-	7.65	-	3.60
4 h.	6.10	-	7.70	8.50	7.35	-	7.20	7.15	7.55	6.40
8 h.	-	-	8.40	-	8.25	-	6.70	8.50	6.85	6.60
12 h.	-	-	8.65	8.35	7.55	-	6.20	-	6.75	6.50
16 h.	-	-	7.50	7.20	-	4.10	-	7.90	6.25	-
20 h.	8.05	-	7.85	-	-	-	7.55	7.50	-	-
24 h.	-	-	-	7.45'	8.30	-	-	6.60	-	5.50'
32 h.	-	-	7.30	6.85	-	-	-	8.00	6.40	5.15
40 h.	-	-	6.35	5.50	-	-	6.45	-	6.45	-
2 d.	-	6.95	4.40	6.13"	5.10	-	7.55	6.63'	6.40	5.40'
3- 4 d.	-	-	3.95	6.75	6.25	-	7.30	6.90	6.85	-
5- 7 d.	-	-	6.75	6.95	7.00	-	-	5.95	7.80	7.15
10-20 d.	-	7.75	6.75	6.95	6.25	-	6.70	5.80	6.60	6.90

Key to symbols - see page i, Appendix I.

Total Acid Soluble Phosphate Levels in Normal Parturient Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Number of Calving III.		IV.			V.		VI.
	No.22.	No.55.	No.18.	No.19.	No.26.	No.20.	No.23.	No.21.
14 d.	-	-	-	-	7.20	-	-	-
12 d.	-	-	6.30	-	7.35	-	-	-
11 d.	-	-	-	-	-	-	-	-
10 d.	-	-	-	-	6.90	-	-	-
9 d.	-	6.90	-	-	-	7.30	5.50	-
8 d.	-	-	5.45	-	-	-	-	6.60
7 d.	5.05	6.90	-	-	8.80	-	-	-
6 d.	-	6.90	6.20	-	-	8.50	6.35	-
5 d.	9.30	6.80	5.05	-	7.75	-	-	5.90
4 d.	-	7.20	-	-	-	11.90	6.95	-
3 d.	6.45	7.40	5.00	-	6.50	13.20	-	6.10
2 d.	6.10	8.15	4.95	4.65	7.25	8.30	7.65	7.45
1 d.	5.50	7.20	5.45'	6.85	-	8.20	10.00	6.45
12 h.	-	6.65	5.20	-	6.40	7.30	-	5.90
4 h.	-	5.70	-	5.30	-	-	-	-
1 h.	-	4.20	-	-	2.30	-	7.65	-
C.	4.60	4.10	4.50	3.40	2.18'	3.70	-	4.15
2 h.	5.00	4.00	4.50	3.00	-	-	6.45	5.00
4 h.	5.20	6.10	4.65	5.35	3.00	4.55	6.35	6.50
8 h.	6.50	5.45	-	-	4.05	5.60	7.85	7.00
12 h.	-	5.95	6.60	3.90	3.85	6.00	-	4.65
16 h.	-	5.90	5.45	4.80	-	5.85	10.00	6.20
20 h.	6.50	5.80	-	-	4.80	6.40	-	-
24 h.	5.35	-	-	-	-	-	-	-
32 h.	-	5.10	7.65	-	5.45	7.10	6.75	5.45
40 h.	-	5.95	-	6.25	5.70	-	-	-
2 d.	5.50	5.05	5.75	5.20	5.73'	5.40'	6.55	4.85
3- 4 d.	5.55	5.75'	-	9.45	6.60'	6.10	6.10	6.70
5- 7 d.	6.25	6.10	-	-	7.78'	6.60	-	6.05
10-20 d.	8.10	6.10	8.95	5.30	7.85	-	-	6.95

Key to symbols - see page i, Appendix I.

Lipid Phosphate Levels in Normal Parturient Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Number of Calving I.				II.					
	No.2.	No.8.	No.57.	No.67.	No.3.	No.5.	No.24.	No.53.	No.54.	No.59.
14 d.	-	-	5.00	2.80	-	-	-	-	-	4.90
12 d.	-	-	4.80	-	-	-	-	6.50	-	3.90
11 d.	-	-	4.70	3.80	-	-	-	-	-	4.90
10 d.	-	-	5.00	-	-	-	-	-	-	4.90
9 d.	-	-	4.90	3.10	-	-	-	-	-	5.00
8 d.	-	-	4.50	-	-	-	2.20	-	-	-
7 d.	-	-	5.00	3.90	-	-	-	7.00	6.30	4.60
6 d.	-	-	4.90	-	-	-	1.20	6.50	-	4.30
5 d.	-	5.75	4.80	3.80	2.80	-	-	6.40	6.00	5.00
4 d.	-	-	4.50	-	-	6.94	1.60	6.50	5.70	5.30
3 d.	-	6.60	4.40	2.00	2.20	-	2.70	6.50	5.70	5.00
2 d.	-	-	4.20	-	2.20	6.40	2.20	6.50	6.60	-
1 d.	7.50	-	4.20	1.30	-	-	1.90'	6.00	6.40	3.00
12 h.	-	-	4.15'	-	2.40	-	-	5.80	5.60	-
4 h.	-	-	4.80	2.50	1.90	-	-	5.50	-	2.80
1 h.	5.25	-	4.60	1.30	3.20	-	2.40	5.10	4.70	-
C.	4.40	3.80	5.00	0.90	-	5.70	3.10	4.80	4.70	3.50
2 h.	-	3.80	-	0.70	3.70	4.90	-	5.50	-	3.40
4 h.	7.38	-	4.00	0.70	3.90	-	1.60	5.50	4.70	4.10
8 h.	-	-	4.60	-	2.90	-	2.40	4.90	5.20	3.80
12 h.	-	4.90	4.60	1.10	2.90	-	1.90	-	5.50	3.50
16 h.	-	-	4.55	1.20	-	6.40	-	5.10	5.40	-
20 h.	4.30	-	5.00	-	-	-	1.80	5.30	-	-
24 h.	-	-	-	1.35'	1.50	-	-	5.80	-	4.35'
32 h.	-	-	5.70	1.30	-	-	-	5.80	5.60	4.50
40 h.	-	-	4.60	2.00	-	-	2.70	-	5.70	-
2 d.	-	-	4.60	1.87"	2.30	-	1.90	5.75'	5.80	4.15'
3- 4 d.	-	-	-	2.20	3.60	6.00	3.60	6.60	6.00	-
5- 7 d.	-	-	5.20	2.10	3.50	-	-	6.70	6.40	4.80
10-20 d.	-	5.30	5.80	3.20	5.40	-	6.20	8.80	7.30	6.60

Key to symbols - see page i, Appendix I.

Lipid Phosphate Levels in Normal Parturient Cows.

Time from Calving.	Number of Calving							
	III.		IV.			V.		VI.
	No.22.	No.55.	No.18.	No.19.	No.26.	No.20.	No.23.	No.21.
14 d.	-	-	-	-	1.80	-	-	-
12 d.	-	-	5.10	-	1.80	-	-	-
11 d.	-	-	-	-	-	-	-	-
10 d.	-	-	-	-	2.00	-	-	-
9 d.	-	8.20	-	-	-	4.50	4.10	-
8 d.	-	-	-	-	-	-	-	3.90
7 d.	-	7.70	-	-	2.20	-	-	-
6 d.	-	7.60	4.70	-	-	3.50	2.70	-
5 d.	2.00	7.80	4.70	-	1.80	-	-	3.70
4 d.	-	7.80	-	-	-	1.40	3.30	-
3 d.	2.40	7.00	5.70	-	1.90	1.40	-	-
2 d.	2.30	6.60	3.60	4.10	2.00	2.90	4.60	2.60
1 d.	2.90	7.20	4.75'	-	-	2.30	3.20	3.10
12 h.	-	7.20	4.50	-	2.10	2.30	-	2.00
4 h.	-	6.20	-	-	-	-	-	-
1 h.	-	6.70	-	-	2.10	-	2.30	-
C.	2.50	6.70	3.60	2.40	1.40'	-	-	2.10
2 h.	2.10	5.40	4.00	2.60	-	-	2.60	2.10
4 h.	2.20	5.40	4.10	3.20	1.90	2.10	3.10	1.10
8 h.	2.10	5.50	-	-	2.30	2.20	2.90	2.60
12 h.	-	6.10	2.50	3.30	2.30	2.20	-	2.10
16 h.	-	6.80	2.90	3.30	-	2.30	-	2.50
20 h.	2.80	6.50	-	-	2.10	2.20	-	-
24 h.	3.70	-	-	-	-	-	-	-
32 h.	-	7.00	1.10	-	1.00	1.80	4.20	1.50
40 h.	-	6.50	-	3.60	1.00	-	-	-
2 d.	2.90	6.70	3.00	3.00	1.90'	2.45'	3.80	1.80
3- 4 d.	3.80	6.75'	-	2.60	2.60'	3.90	4.90	2.00
5- 7 d.	2.40	6.90	-	-	3.50'	5.70	-	3.70
10-20 d.	4.10	7.10	3.00	6.00	3.70	-	-	5.50

Key to symbols - see page i, Appendix I.

Total Phosphate Levels in Normal Parturient Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Number of Calving I. No.2.	No.8.	No.57.	No.67.	II. No.3.	No.5.	No.24.	No.53.	No.54.	No.59.
14 d.	-	-	11.30	10.50	-	-	-	-	-	12.90
12 d.	-	-	12.20	-	-	-	-	13.70	-	11.60
11 d.	-	-	10.40	9.60	-	-	-	-	-	10.80
10 d.	-	-	11.50	-	-	-	-	-	-	11.00
9 d.	-	-	11.30	10.50	-	-	-	-	-	12.20
8 d.	-	-	10.90	-	-	-	10.70	-	-	-
7 d.	-	-	11.10	9.60	-	-	-	13.00	12.90	10.90
6 d.	-	-	10.50	-	-	-	9.60	14.50	-	11.50
5 d.	-	14.25	11.90	9.50	12.50	-	-	13.80	12.40	12.70
4 d.	-	-	12.10	-	-	12.00	9.30	14.00	11.90	11.80
3 d.	-	13.20	12.50	10.00	10.70	-	10.60	13.50	12.00	11.00
2 d.	-	-	10.40	-	10.20	13.90	10.40	13.80	13.40	-
1 d.	10.25	-	10.00	9.00	-	-	9.40'	13.80	13.50	10.90
12 h.	-	-	10.30	-	9.85'	-	-	11.80	12.40	-
4 h.	-	-	10.70'	7.60	7.90	-	-	12.70	-	8.60
1 h.	6.00	-	10.20	7.00	8.20	-	7.50	10.40	10.30	-
C.	6.50	11.50	11.20	-	-	11.10	5.70'	10.40	9.40	6.20
2 h.	-	10.70	-	8.90	9.60	11.40	-	12.90	-	7.60
4 h.	8.50	-	11.90	9.30	11.10	-	8.40	12.50	12.00	8.60
8 h.	-	-	13.50	-	10.70	-	8.50	13.40	11.80	9.70
12 h.	-	15.80	14.30	9.00	-	-	7.90	-	11.60	9.90
16 h.	-	-	12.30	9.30	-	12.70	-	13.40	11.30	-
20 h.	-	-	12.00	-	-	-	7.50	13.00	-	-
24 h.	-	-	-	9.15'	9.40	-	-	12.80	-	9.15'
32 h.	-	-	12.70	8.30	-	-	-	13.70	12.00	8.70
40 h.	-	-	11.10	8.10	-	-	8.90	-	12.00	-
2 d.	-	13.70	9.50	8.37"	7.40	-	9.40	12.00'	11.00	8.25'
3- 4 d.	-	-	9.00	9.30	9.50	13.00	9.70	13.20	11.70	-
5- 7 d.	-	-	11.60	9.30	11.40	-	-	12.90	13.20	11.50
10-20 d.	-	14.30	13.30	10.20	11.10	-	12.00	13.20	12.60	13.20

Key to symbols - see page i, Appendix I.

Total Phosphate Levels in Normal Parturient Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Number of Calving							
	III.		IV.			V.		VI.
	No.22.	No.55.	No.18.	No.19.	No.26.	No.20.	No.23.	No.21.
14 d.	-	-	-	-	8.80	-	-	-
12 d.	-	-	11.40	-	8.80	-	-	-
11 d.	-	-	-	-	-	-	-	-
10 d.	-	-	-	-	9.80	-	-	-
9 d.	-	12.60	-	-	-	10.70	9.80	-
8 d.	-	-	10.60	-	-	-	-	11.30
7 d.	6.90	13.60	-	-	9.90	-	-	-
6 d.	-	13.30	10.70	-	-	12.00	9.10	-
5 d.	10.30	13.50	10.50	-	8.80	-	-	11.20
4 d.	-	14.80	-	-	-	11.60	9.40	-
3 d.	8.00	14.00	10.80	-	8.30	12.80	-	9.80
2 d.	8.60	13.80	11.00	8.50	8.20	10.60	11.90	10.20
1 d.	9.40	13.60	10.55'	8.30	-	9.80	13.20	9.80
12 h.	-	13.30	10.40	-	8.10	9.10	-	9.60
4 h.	-	12.10	-	8.20	-	-	-	-
1 h.	-	10.00	-	-	4.70	-	10.90	-
C.	6.80	9.50	8.40	6.10	4.70'	6.10	-	6.00
2 h.	6.40	9.00	8.70	5.70	-	-	10.00	6.50
4 h.	7.80	10.50	8.70	7.70	5.20	6.50	10.90	7.50
8 h.	8.80	10.70	-	-	7.80	7.40	10.60	8.10
12 h.	-	11.60	8.50	7.10	7.30	8.00	-	7.30
16 h.	-	11.40	9.20	7.40	-	8.80	10.20	8.20
20 h.	9.20	11.90	-	-	8.20	8.80	-	-
24 h.	8.10	-	-	-	-	-	-	-
32 h.	-	10.50	8.60	-	7.50	10.20	11.30	8.00
40 h.	-	11.60	-	9.80	7.50	-	-	-
2 d.	7.10	10.90	9.30	8.60	9.20'	8.80'	10.30	7.60
3- 4 d.	7.70	11.30'	-	10.80	8.65'	10.00	10.70	8.70
5- 7 d.	9.60	12.50	-	-	10.55'	12.40	-	9.90
10-20 d.	12.40	15.00	12.90	11.00	11.90	-	-	12.20

Key to symbols - see page i, Appendix I.

Phosphate Changes in Normal Parturient Cows.

Inorganic Phosphate.*

No. of Calving.	Cow No.	(Before) 2 d.	C.	Time from Calving 4 h.	24-40 h.	(After) 2 d.	10-20 d.
I.	12.	5.20	4.35	7.25	5.25'	5.35	6.50
	57.	5.95	5.50	6.95	5.90	3.15	5.85
II.	4.	6.10	3.80	6.15	7.05	5.85	6.55
	53.	6.30	5.60	6.65	6.40'	5.65'	4.95
	54.	6.35	4.15	6.15	5.90	4.65	4.80
III.	11.	5.50'	3.85	5.85	4.40	5.30'	5.10
	14.	5.20	3.25	4.60	3.10	3.90	7.30
	15.	6.00	3.00	4.05	5.40	5.70	7.00
	22.	4.80	3.50	4.90	4.60	5.00	7.40
	27.	4.90	3.60	2.20	4.30	4.05'	5.70
	55.	6.95	3.10	5.00	3.50	2.00	5.20
IV.	18.	4.60	3.90	3.50	4.60	4.18	6.80
	26.	5.15	1.55'	2.20	4.10	4.50'	4.90
VI.	21.	6.60	4.10	5.90	4.50	4.00	6.20

Total Acid Soluble Phosphate.*

No. of Calving.	Cow No.	(Before) 2 d.	C.	Time from Calving 4 h.	24-40 h.	(After) 2 d.	10-20 d.
I.	57.	7.20	6.10	7.70	7.30	4.40	6.75
II.	53.	7.60	6.80	7.15	7.30'	6.63'	5.80
	54.	8.00	4.45	7.55	6.40	6.40	6.60
III.	22.	6.10	4.60	5.20	5.35	5.50	8.10
	55.	8.15	4.10	6.10	5.10	5.05	6.10
IV.	18.	4.95	4.50	4.65	7.65	5.75	8.95
	26.	7.25	2.18'	3.00	5.45	5.73'	7.85
VI.	21.	7.45	4.15	6.50	5.45	4.85	6.95

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Phosphate Changes in Normal Parturient Cows.

Lipid Phosphate.*

No. of Calving.	Cow No.	(Before) 2 d.	C.	Time from Calving 4 h.	24-40 h.	(After) 2 d.	10-20 d.
I.	57.	4.20	5.00	4.00	5.70	4.60	5.80
II.	53.	6.50	4.80	5.50	5.80'	5.75'	8.80
	54.	6.60	4.70	4.70	5.60	5.80	7.30
III.	22.	2.30	2.50	2.20	3.70	2.90	4.10
	55.	6.60	6.70	5.40	7.00	6.70	7.10
IV.	18.	3.60	3.60	4.10	1.10	3.00	3.00
	26.	2.00	1.40'	1.90	1.00	1.90'	3.70
VI.	21.	2.60	2.10	1.10	1.50	1.80	5.50

Total Phosphate.*

No . of Calving.	Cow No.	(Before) 2 d.	C.	Time from Calving 4 h.	24-40 h.	(After) 2 d.	10-20 d.
I.	57.	10.40	11.20	11.90	12.70	9.50	13.30
II.	53.	13.80	10.40	12.50	13.25'	12.00'	13.20
	54.	13.40	9.40	12.00	12.00	11.00	12.60
III.	22.	8.60	6.80	7.80	8.10	7.10	12.40
	55.	13.80	9.50	10.50	10.50	10.90	15.00
IV.	18.	11.00	8.40	8.70	8.60	9.30	12.90
	26.	8.20	4.70'	5.20	7.50	9.20'	11.90
VI.	21.	10.20	6.00	7.50	8.00	7.60	12.20

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Phosphate Changes before Calving in Normal Parturient Cows.

Inorganic Phosphate.*

No. of Calving.	Cow No.	Time before Calving 2 d.	1 d.	12 h.	C.
I.	12.	5.20	6.05	5.20	4.35
	17.	6.40	5.30'	5.10	4.60
	57.	5.95	5.40	5.55'	5.50
II.	4.	6.10	6.80'	5.60	3.80
	16.	5.90	5.40	5.20	3.20
	53.	6.30	6.40	5.30	5.60
	54.	6.35	6.25	6.80	4.15
III.	27.	4.90	4.70	4.85	3.60
	55.	6.95	6.20	5.40	3.10
IV.	18.	4.60	4.70'	4.60	3.90
V.	20.	6.50	5.50	5.30	2.20
VI.	21.	6.60	5.55	5.30	4.10
	28.	4.55	4.80	3.90	2.40

Total Acid Soluble Phosphate.*

No. of Calving.	Cow No.	Time before Calving 2 d.	1 d.	12 h.	C.
I.	57.	7.20	6.60	6.90'	6.10
II.	53.	7.60	7.75	6.75	6.80
	54.	8.00	7.25	7.30	4.45
III.	55.	8.15	7.20	6.65	4.10
IV.	18.	4.95	5.45'	5.20	4.50
V.	20.	8.30	8.20	7.30	3.70
VI.	21.	7.45	6.45	5.90	4.15

Total Phosphate.*

No. of Calving.	Cow No.	Time before Calving 2 d.	1 d.	12 h.	C.
I.	57.	10.40	10.00	10.30	11.20
II.	53.	13.80	13.80	11.80	10.40
	54.	13.40	13.50	12.40	9.40
III.	55.	13.80	13.60	13.30	9.50
IV.	18.	11.00	10.55'	10.40	8.40
V.	20.	10.60	9.80	9.10	6.10
VI.	21.	10.20	9.80	9.60	6.00

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Phosphate Changes after Calving in Normal Parturient Cows.

Inorganic Phosphate.*

No. of Calving.	Cow No.	Time from Calving C.	4 h.	12 h.	24-40 h.
I.	12.	4.35	7.25	7.20	5.25'
	57.	5.50	6.95	7.30	5.90
	67.	4.10	5.60	5.45	4.75"
II.	54.	4.15	6.15	6.05	5.90
	59.	3.40	5.25	5.70	4.80"
III.	15.	3.00	4.05	6.50	5.40
	27.	3.60	2.20	2.50	4.30
	55.	3.10	5.00	4.90	3.50
IV.	18.	3.90	3.50	4.00	4.60
	26.	1.55'	2.20	3.10	4.10
V.	20.	2.20	3.70	4.50	5.90
VI.	21.	4.10	5.90	4.70	4.50

Total Acid Soluble Phosphate.*

No. of Calving.	Cow No.	Time from Calving C.	4 h.	12 h.	24-40 h.
I.	57.	6.10	7.70	8.65	7.30
	67.	5.05	8.50	8.35	7.15"
II.	54.	4.45	7.55	6.75	6.40
	59.	3.60	6.40	6.50	5.33"
III.	55.	4.10	6.10	5.95	5.10
IV.	18.	4.50	4.65	6.60	7.65
	26.	2.18'	3.00	3.85	5.45
V.	20.	3.70	4.55	6.00	7.10
VI.	21.	4.15	6.50	4.65	5.45

Total Phosphate.*

No. of Calving.	Cow No.	Time from Calving C.	4 h.	12 h.	24-40 h.
I.	57.	11.20	11.90	14.30	12.70
II.	54.	9.40	12.00	11.60	12.00
	59.	6.20	8.60	9.90	8.93"
III.	55.	9.50	10.50	11.60	10.50
IV.	18.	8.40	8.70	8.50	8.60
	26.	4.70'	5.20	7.30	7.50
V.	20.	6.10	6.50	8.00	10.20
VI.	21.	6.00	7.50	7.30	8.00

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Calcium/Total Phosphate Ratios in Normal Parturient Cows.

Time from Calving.	Number of Calving I.				II.					
	No.2.	No.8.	No.57.	No.67.	No.3.	No.5.	No.24.	No.53.	No.54.	No.59.
14 d.	-	-	0.88	1.01	-	-	-	-	-	0.78
12 d.	-	-	0.89	-	-	-	-	0.76	-	0.83
11 d.	-	-	0.98	1.06	-	-	-	-	-	0.92
10 d.	-	-	0.88	-	-	-	-	-	-	0.92
9 d.	-	-	0.91	0.99	-	-	-	-	-	0.85
8 d.	-	-	0.94	-	-	-	0.99	-	-	-
7 d.	-	-	0.96	1.16	-	-	-	0.82	0.83	0.89
6 d.	-	-	1.02	-	-	-	1.18	0.68	-	0.86
5 d.	-	0.74	0.84	1.13	0.93	-	-	0.76	0.85	0.79
4 d.	-	-	0.87	-	-	0.83	1.19	0.71	0.90	0.90
3 d.	-	0.83	0.83	1.14	1.05	-	1.00	0.73	0.87	0.87
2 d.	-	-	0.93	-	1.06	0.84	1.03	0.74	0.75	-
1 d.	0.99	-	0.99	1.24	-	-	1.07	0.72	0.82	0.91
12 h.	-	-	1.02	-	0.97	-	-	0.85	0.82	-
4 h.	-	-	0.90	1.48	1.21	-	-	0.79	-	1.11
1 h.	-	-	0.93	1.52	1.16	-	1.33	0.95	0.98	-
C.	1.23	0.89	0.88	-	-	0.93	1.67	0.95	1.07	1.47
2 h.	-	-	-	1.17	1.05	0.77	-	0.77	-	1.06
4 h.	1.03	-	0.81	1.15	0.86	-	1.20	0.78	0.86	1.08
8 h.	-	-	0.74	-	0.85	-	1.21	0.70	0.89	0.94
12 h.	-	0.69	0.66	1.08	-	-	1.21	-	0.82	0.82
16 h.	-	-	0.76	1.07	-	0.71	-	0.72	0.83	-
20 h.	-	-	0.70	-	-	-	1.28	0.68	-	-
24 h.	-	-	-	1.02	0.93	-	-	0.64	-	0.90'
32 h.	-	-	0.70	1.10	-	-	-	0.62	0.75	0.90
40 h.	-	-	0.81	1.13	-	-	1.10	-	0.70	-
2 d.	-	0.73	0.95	1.11	1.13	-	1.02	0.74	0.90	0.94
3- 4 d.	-	-	0.93	1.14	0.97	0.81	1.01	0.76	0.94	-
5- 7 d.	-	-	0.89	1.18	0.79	-	-	0.76	0.70	0.79
10-20 d.	-	0.74	0.76	1.06	0.94	-	0.88	0.75	0.71	0.70

Key to symbols - see page i, Appendix I.

Calcium/Total Phosphate Ratios in Normal Parturient Cows.

Time from Calving.	Number of Calving III.		IV.			V.		VI.
	No.22.	No.55.	No.18.	No.19.	No.26.	No.20.	No.23.	No.21.
14 d.	-	-	-	-	1.46	-	-	-
12 d.	-	-	1.04	-	1.19	-	-	-
11 d.	-	-	-	-	-	-	-	-
10 d.	-	-	-	-	1.09	-	-	-
9 d.	-	0.80	-	-	-	1.09	1.10	-
8 d.	-	-	1.09	-	-	-	-	0.99
7 d.	1.52	0.79	-	-	1.03	-	-	-
6 d.	-	0.81	1.12	-	-	0.94	1.16	-
5 d.	1.12	0.76	1.05	-	1.22	-	-	0.97
4 d.	-	0.70	-	-	-	0.79	1.16	-
3 d.	1.34	0.74	1.19	-	1.28	0.69	-	1.05
2 d.	1.30	0.78	1.17	1.27	1.27	1.09	0.94	1.10
1 d.	1.14	0.76	1.11	1.22	-	1.27	0.88	1.14
12 h.	-	0.79	1.05	-	1.34	1.12	-	1.17
4 h.	-	0.72	-	1.22	-	-	-	-
1 h.	-	0.86	-	-	1.77	-	0.92	-
C.	1.53	0.84	1.18	1.39	1.79	1.16	-	1.44
2 h.	1.52	0.97	1.45	1.46	-	-	0.87	1.42
4 h.	1.25	0.73	1.28	1.23	1.26	1.34	0.88	1.26
8 h.	1.17	0.81	-	-	0.88	1.16	0.95	1.18
12 h.	-	0.79	1.16	1.31	1.15	1.04	-	1.29
16 h.	-	0.75	0.90	1.44	-	0.94	0.95	1.09
20 h.	0.98	0.63	-	-	1.11	0.99	-	-
24 h.	1.22	-	-	-	-	-	-	-
32 h.	-	0.76	1.19	-	1.18	0.98	0.85	1.27
40 h.	-	0.75	-	1.02	1.29	-	-	-
2 d.	1.27	0.77	1.09	1.27	1.08	1.16	0.86	1.29
3- 4 d.	1.19	0.81	-	1.16	1.24	0.95	0.88	1.21
5- 7 d.	1.03	0.74	-	-	0.96	0.83	-	1.05
10-20 d.	0.87	0.66	0.77	1.01	0.87	-	-	0.87

Key to symbols - see page i, Appendix I.

Calcium/Phosphate Ratios in Normal Parturient Cows.

Calcium/Inorganic Phosphate Ratios.

No. of Calving.	Cow No.	(Before) 2 d.	C.	Time from Calving 4 h.	24-40 h.	(After) 2 d.	10-20 d.
I.	12.	2.10	2.52	1.76	2.23	2.03	1.83
	57.	1.63	1.78	1.44	1.52	2.36	1.73
II.	4.	1.72	2.56	1.53	1.31	1.56	1.60
	53.	1.63	1.77	1.46	1.32	1.59	2.00
	54.	1.59	2.42	1.68	1.51	2.13	1.88
III.	14.	1.84	2.62	1.89	2.78	2.49	1.63
	15.	1.92	3.40	2.51	1.85	2.14	1.55
	22.	2.33	2.98	1.98	2.14	1.80	1.47
	27.	2.21	2.47	3.92	1.62	2.21	1.86
	55.	1.55	2.58	1.54	2.29	4.20	1.91
IV.	18.	2.75	2.54	3.18	2.22	2.43	1.46
	26.	2.02	5.16'	2.98	2.16	2.21	2.10
VI.	21.	1.70	2.11	1.60	2.27	2.45	1.70

Calcium/Total Acid Soluble Phosphate Ratios.

No. of Calving.	Cow No.	(Before) 2 d.	C.	Time from Calving 4 h.	24-40 h.	(After) 2 d.	10-20 d.
I.	57.	1.35	1.61	1.25	1.23	2.02	1.50
II.	53.	1.35	1.45	1.36	1.16	1.35	1.71
	54.	1.26	2.26	1.37	1.39	1.54	1.36
III.	22.	1.84	2.26	1.87	1.84	1.64	1.34
	55.	1.32	1.95	1.26	1.57	1.66	1.63
IV.	18.	2.56	2.20	2.39	1.34	1.76	1.11
	26.	1.43	3.68	2.18	1.64	1.74	1.31
VI.	21.	1.50	2.08	1.45	1.87	2.02	1.53

Calcium/Total Phosphate Ratios.

No. of Calving.	Cow No.	(Before) 2 d.	C.	Time from Calving 4 h.	24-40 h.	(After) 2 d.	10-20 d.
I.	57.	0.93	0.88	0.81	0.70	0.95	0.76
II.	53.	0.74	0.95	0.78	0.63'	0.74	0.75
	54.	0.75	1.07	0.86	0.75	0.90	0.71
III.	22.	1.30	1.53	1.25	1.22	1.27	0.87
	55.	0.78	0.84	0.73	0.76	0.77	0.66
IV.	18.	1.17	1.18	1.28	1.19	1.09	0.77
	26.	1.27	1.79	1.26	1.18	1.08	0.87
VI.	21.	1.10	1.44	1.26	1.27	1.29	0.87

Key to symbols - see page i, Appendix I.

Phosphate Changes before the Onset of Milk Fever.

Time from Calving.	Inorganic Phosphate.*				Tot. Acid Soluble P.*				Lipid Phosphate.*				Total Phosphate.*			
	No. 29.	No. 32.	No. 31.	No. 66.	No. 29.	No. 32.	No. 31.	No. 66.	No. 29.	No. 32.	No. 31.	No. 66.	No. 29.	No. 32.	No. 31.	No. 66.
14 d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12 d.	-	-	-	5.13'	-	-	-	6.23'	-	-	-	5.00'	-	-	-	11.45'
11 d.	-	-	-	5.30	-	-	-	7.90	-	-	-	3.70	-	-	-	12.30
10 d.	-	5.00	-	5.10	-	5.90	-	6.85	-	5.50	-	4.00	-	9.10	-	10.60
9 d.	-	-	-	5.10	-	-	-	6.75	-	-	-	4.60	-	-	-	10.40
8 d.	-	4.55	-	5.30	-	4.75	-	6.60	-	4.10	-	5.40	-	8.70	-	11.20
7 d.	-	-	-	5.55	-	-	-	7.10	-	-	-	5.00	-	-	-	11.30
6 d.	-	4.45	4.65	4.35	-	5.00	4.90	6.05	-	4.20	3.20	4.90	-	8.20	8.50	10.40
5 d.	-	5.25	4.70	5.50	-	5.75	5.10	7.10	-	4.60	2.50	4.60	-	8.80	9.50	11.20
4 d.	-	5.10	5.10	5.00	-	5.90	4.90	6.75	-	5.10	4.70	4.50	-	9.00	9.10	10.80
3 d.	-	5.25	4.80	4.85	-	5.60	4.60	7.60	-	5.10	4.00	2.80	-	7.90	8.40	11.00
2 d.	-	5.10	-	4.85	-	5.20	-	7.25	-	4.50	-	3.20	-	9.00	-	10.80
1 d.	-	5.48'	3.90	4.95	-	6.38'	3.65	6.05	-	4.10'	5.60	3.90	-	9.10'	7.20	10.50
12 h.	5.60	-	-	4.35	7.30	-	-	6.50	3.80	-	-	2.30	10.00	-	-	10.30
4 h.	-	0.90	3.40	-	-	1.60	3.55	-	-	3.30	2.90	-	-	3.80	6.70	-
1 h.	-	0.60	-	-	-	1.40	-	-	-	3.20	-	-	-	3.50	-	-
C.	2.15	0.50	-	1.30	2.65	1.50	-	2.40	3.00	2.90	-	3.90	6.90	3.00	-	6.70
2 h.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4 h.	2.70'	-	-	1.60	3.20'	-	-	2.25	2.85'	-	-	3.70	7.70'	-	-	6.60
8 h.	-	-	-	2.40	-	-	-	3.15	-	-	-	3.00	-	-	-	7.20
12 h.	-	-	1.50	1.00	-	-	1.50	2.20	-	-	3.10	3.60	-	-	4.50	6.40
16 h.	-	-	1.15	1.45	-	-	1.55	2.45'	-	-	2.90	3.90	-	-	4.70	6.50
20 h.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24 h.	1.18'	-	-	1.40	1.63'	-	-	1.70	2.55'	-	-	4.50	6.15'	-	-	6.70
32 h.	0.60	-	-	0.75'	1.05	-	-	1.35'	2.80	-	-	5.20'	6.20	-	-	7.05'

Cows 31 and 66 were pre-partum milked.

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Inorganic Phosphate Levels in Milk Fever Cases, treated with Calcium Borogluconate.*

Satisfactory Response.

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
29-1	32 h.	0.60	-	1.55	1.45	1.75	2.95	-	2.30
31-2	48 h.	2.05	-	3.20	3.30	4.20	-	5.10	-
36-1	48 h.	1.60	3.20	-	3.35	4.20	4.80	-	4.50
63-1	27 h.	0.45	-	1.85	2.70	-	2.60	-	2.30
85-3	54 h.	2.00	-	4.69	-	-	4.77	0.95	4.33
92-3	38 h.	2.16	3.02	3.42	-	-	-	3.49	2.54
66-2	34 h.	1.55	2.37"	2.25	2.65	3.10	2.65	2.35	3.65
88-1	30 h.	0.29	0.44	0.42	0.65	0.72	0.70	1.50	3.58
94-1	48 h.	1.35	2.40	2.31	2.03	1.89	1.86	2.81	3.17
96-1	36 h.	1.94	3.19	3.53	3.88	4.50	4.60	3.78	4.62
111-1	16 h.	0.95	2.07	2.25	2.00	1.20	2.07	1.73	2.92

Unsatisfactory Response.

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-2	10 h.	0.45	-	0.65	0.75	1.11	-	0.90	-
44-1	12 h.	1.00	1.30	-	1.50	1.60	1.00	0.90	-
61-1	18 h.	0.60	1.65	-	1.70	2.05	-	1.35	2.20
62-1	8 h.	0.85	1.20	-	1.65	-	-	2.45	-
65-1	48 h.	1.95	2.20	-	-	-	2.25	2.50	-
85-1	6 h.	1.75	2.63	-	-	-	2.76	1.39	1.67
89-1	-5 h.	0.94	1.88	2.16	-	1.43	2.00	-	1.27
31-1	12 h.	1.15	1.50	1.70	2.40	2.50	2.40	1.90	1.90
32-1	1 h.	0.50	0.85	0.85	0.90	1.00	0.82"	0.40	0.45
81-1	-3 h.	2.25	2.60	2.08	3.50	4.18	2.55	2.63	2.86
84-1	24 h.	0.82	2.00	1.93	2.63	1.78	1.90	2.32	1.02
92-1	-10 h.	0.77	0.76	1.16	1.38	1.80	1.56	1.68	2.38

' Time of treatment after calving (hours). Minus sign indicates time before calving.

" Calculated according to Snedecor (90).

* Mgms. P./100 ml. Plasma.

Total Acid Soluble Phosphate Levels in Milk Fever Cases, treated with Calcium Borogluconate.*

Satisfactory Response.

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
29-1	32 h.	1.05	-	1.70	1.65	1.90	3.55	-	3.75
31-2	48 h.	3.55	-	4.75	5.35	6.90	-	6.95	-
36-1	48 h.	2.05	3.80	4.25	4.45	-	4.90	-	4.95
63-1	27 h.	2.65	-	3.25	3.85	-	4.55	-	4.25
85-3	54 h.	5.50	-	6.60	-	-	7.25	7.25	6.25
92-3	38 h.	2.50	3.40	3.75	-	-	-	3.55	3.00
66-2	34 h.	2.30	3.21"	3.15	3.30	4.05	3.90	3.55	4.90
88-1	30 h.	0.25	0.25	0.30	0.70	0.90	2.55	3.25	3.90
94-1	48 h.	1.35	2.50	2.40	1.95	2.10	1.80	2.85	3.40
96-1	36 h.	2.10	3.75	3.90	4.10	4.90	4.90	4.00	4.80
111-1	16 h.	1.25	2.05	2.25	2.05	1.35	2.25	2.00	2.90

Unsatisfactory Response.

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-2	10 h.	1.15	-	0.60	0.60	1.15	-	1.85	-
44-1	12 h.	1.55	2.05	-	2.15	2.55	1.85	1.60	-
61-1	18 h.	1.30	1.90	-	2.35	2.75	-	1.50	2.90
62-1	8 h.	0.95	1.95	-	2.35	-	-	3.00	-
65-1	48 h.	2.50	2.90	-	-	-	2.85	3.20	-
85-1	6 h.	3.40	4.40	-	-	-	4.05	3.60	2.60
89-1	-5 h.	1.55	2.05	2.40	-	1.95	2.30	-	2.15
31-1	12 h.	1.55	1.45	2.60	3.10	2.35	3.25	3.40	2.60
32-1	1 h.	1.50	1.60	1.60	1.85	1.40	1.69"	1.15	1.15
81-1	-3 h.	2.90	4.00	4.05	4.50	4.75	3.85	4.45	5.05
84-1	24 h.	1.40	3.00	2.75	3.15	3.50	3.15	3.60	1.35
92-1	-10 h.	1.20	1.60	1.70	1.90	2.30	2.00	2.15	3.00

' Time of treatment after calving (hours).
Minus sign indicates time before calving.

" Calculated according to Snedecor (90).

Underlined values are those considered to show the maximum change initiated by Calcium Injection.

* Mgms. P./100 ml. Plasma.

Lipid Phosphate Levels in Milk Fever Cases, treated with Calcium Borogluconate.*

Satisfactory Response.

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
29-1	32 h.	2.80	-	3.10	3.00	3.10	2.00	-	1.90
31-2	48 h.	1.80	-	2.10	2.70	1.80	-	2.40	-
36-1	48 h.	4.60	5.10	-	4.90	5.30	5.00	-	5.70
63-1	27 h.	2.90	-	3.30	3.40	-	3.00	-	2.90
85-3	54 h.	3.80	-	3.60	-	-	4.75	3.85	-
92-3	38 h.	3.80	3.10	3.55	-	-	-	3.75	3.20
66-2	34 h.	5.10	-	5.30	5.40	5.80	5.30	5.30	5.30
88-1	30 h.	2.75	3.15	2.70	3.00	2.80	2.75	2.45	3.30
94-1	48 h.	2.75	2.40	2.60	3.15	3.40	2.15	2.15	2.40
96-1	36 h.	3.60	2.45	3.00	3.00	3.00	3.30	3.40	3.60
111-1	16 h.	3.95	4.25	4.15	4.05	4.45	4.15	3.80	4.70

Unsatisfactory Response.

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-2	10 h.	1.70	-	3.10	2.70	2.50	-	2.70	-
44-1	12 h.	5.80	5.60	-	4.10	5.30	6.00	5.10	-
61-1	18 h.	2.30	2.60	-	2.20	2.20	-	2.20	2.20
62-1	8 h.	1.10	1.10	-	1.30	-	-	1.30	-
65-1	48 h.	3.60	3.60	-	-	-	3.90	3.50	-
85-1	6 h.	3.70	3.50	-	-	-	3.55	2.80	2.70
89-1	-5 h.	0.95	1.65	1.60	-	1.75	1.40	-	2.35
31-1	12 h.	2.90	3.40	3.30	3.00	3.20	3.60	2.60	2.70
32-1	1 h.	2.90	2.80	2.90	2.70	2.60	-	2.90	1.70
81-1	-3 h.	4.30	3.50	3.75	3.90	3.75	3.65	3.55	4.15
84-1	24 h.	6.30	6.50	6.30	6.60	7.00	5.60	6.00	8.00
92-1	-10 h.	2.00	2.10	2.30	2.70	2.50	2.10	1.95	2.40

' Time of treatment after calving (hours).
Minus sign indicates time before calving.

* Mgms. P./100 ml. Plasma.

Total Phosphate Levels in Milk Fever Cases, treated with Calcium Borogluconate.*

Satisfactory Response.

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
29-1	32 h.	6.20	-	6.60	6.40	6.60	8.30	-	6.80
31-2	48 h.	6.00	-	6.80	7.60	8.30	-	9.80	-
36-1	48 h.	7.00	8.30	-	8.70	9.20	10.80	-	9.30
63-1	27 h.	6.00	-	6.50	7.40	-	8.20	-	8.10
85-3	54 h.	9.30	-	10.20	-	-	12.00	11.10	10.10
92-3	38 h.	6.30	6.50	7.30	-	-	-	7.30	6.20
66-2	34 h.	7.40	8.25"	8.80	8.90	9.50	8.90	8.50	9.60
88-1	30 h.	3.00	3.40	3.00	3.70	3.70	5.30	5.70	7.20
94-1	48 h.	4.10	4.90	5.00	5.10	5.50	3.95	5.00	5.80
96-1	36 h.	5.70	6.20	6.90	7.10	7.90	8.20	7.40	8.40
111-1	16 h.	5.20	6.30	6.40	6.10	5.80	6.40	5.80	7.60

Unsatisfactory Response.

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-2	10 h.	2.60	-	2.80	2.90	2.50	-	3.00	-
44-1	12 h.	7.30	7.00	-	7.60	7.50	7.60	6.50	-
61-1	18 h.	3.80	5.10	-	5.20	5.00	-	4.00	4.80
62-1	8 h.	3.30	3.30	-	4.10	-	-	4.00	-
65-1	48 h.	6.60	6.70	-	-	-	7.10	7.30	-
85-1	6 h.	7.10	7.90	-	-	-	7.60	6.40	5.30
89-1	-5 h.	2.50	3.70	4.00	-	3.70	3.70	-	4.50
31-1	12 h.	4.70	4.70	5.00	5.70	6.40	7.10	6.80	6.50
32-1	1 h.	3.00	3.50	3.60	3.10	3.90	3.20"	3.00	2.60
81-1	-3 h.	7.20	7.50	7.80	8.40	8.50	7.50	8.00	9.20
84-1	24 h.	7.80	9.10	9.50	10.20	9.70	8.30	8.30	9.50
92-1	-10 h.	3.20	3.70	4.00	4.60	4.80	4.10	4.10	5.40

' Time of treatment after calving (hours). Minus sign indicates time before calving.

" Calculated according to Snedecor (90).

Underlined values are those considered to show the maximum change initiated by Calcium Injection.

* Mgms. P./100 ml. Plasma.

Plasma Phosphates Before and After Treatment, for Cases of Milk Fever that Responded Satisfactorily to Calcium Therapy.

Cow No. & Treat. No.	Time' of Treat.	Inorganic P.*			Total Acid Sol. P.*			Lipid P.*			Total P.*			Time of Sample III."
		Before Treat.	¼-½ hr.	Sample III.	Before Treat.	¼-½ hr.	Sample III.	Before Treat.	¼-½ hr.	Sample III.	Before Treat.	¼-½ hr.	Sample III.	
33-1	60 hr.	2.20	3.30	4.80	2.60	3.30	6.00	2.30	3.50	2.50	5.30	6.40	9.20	8 hr.
38-2	48 hr.	1.10	2.20	3.20	2.00	3.10	3.90	4.40	4.80	4.30	5.60	6.60	8.00	7 hr.
42-1	20 hr.	2.50	3.00	4.05	3.05	5.15	5.20	2.80	2.50	3.00	6.10	7.10	8.20	20 hr.
43-1	16 hr.	2.50	3.60	3.30	3.05	4.55	5.30	2.80	3.50	2.20	6.30	8.00	8.00	29 hr.
45-1	6 hr.	0.80	2.00	4.55	1.75	2.65	5.00	1.75	2.35	2.80	3.50	5.00	7.80	8 hr.
46-1	4 hr.	1.00	1.35	3.30	2.35	2.30	5.20	2.30	2.50	3.10	4.80	4.40	7.10	9 hr.
47-2	4 hr.	4.15	-	5.10	6.05	-	6.45	3.80	-	4.10	9.20	-	9.60	1 hr.
48-2	12 hr.	1.15	1.20	3.20	1.95	2.10	4.45	3.10	3.20	3.80	4.90	4.90	7.90	9 hr.
50-1	26 hr.	0.80	1.35	2.70	1.50	2.10	3.45	6.30	5.60	6.30	7.00	8.40	9.00	4 hr.
62-2	14 hr.	2.45	-	3.50	3.00	-	4.25	1.30	-	1.30	4.00	-	5.00	2 hr.
64-1	-2 hr.	1.10	1.95	2.60	1.20	2.75	4.00	2.10	1.30	1.30	4.00	4.80	6.00	6 hr.
68-1	30 hr.	1.80	2.20	3.70	1.95	2.35	3.75	2.90	3.30	3.20	5.60	5.70	7.20	2 hr.
69-1	36 hr.	1.85	2.30	2.80	3.00	3.95	4.45	3.10	3.70	2.70	4.70	7.30	6.90	2 hr.
74-1	4 hr.	2.46	5.22	4.08	3.10	5.95	4.80	4.60	4.50	3.90	6.70	9.80	8.60	3 hr.
76-1	20 hr.	2.16	3.04	-	2.90	4.50	-	1.30	0.80	-	4.20	5.30	-	
77-1		4.03	4.33	-	5.30	5.45	-	3.30	3.15	-	8.60	8.60	-	
78-1	6 hr.	0.53	0.91	-	1.80	3.15	-	2.90	1.65	-	4.70	4.80	-	
79-1	6 hr.	1.45	2.50	-	2.10	3.40	-	2.70	2.40	-	4.80	5.80	-	
83-1	22 hr.	0.96	-	2.89	1.15	-	3.55	3.55	-	2.85	4.70	-	6.40	5 hr.
84-2	48 hr.	2.60	3.68	4.49	2.90	4.80	5.70	6.40	6.40	6.30	9.90	10.90	11.60	5 hr.
87-1		0.06	0.13	-	0.75	1.00	-	2.85	2.60	-	3.60	3.60	-	
91-2	36 hr.	1.46	2.20	3.02	1.95	2.90	4.00	2.35	2.40	2.90	4.30	5.30	6.90	14 hr.
93-2	48 hr.	2.69	4.33	-	3.05	4.75	-	3.55	3.75	-	6.60	8.50	-	
98-2	48 hr.	2.49	3.30	-	2.75	3.75	-	3.35	3.25	-	6.10	7.00	-	
100-1	4 mth.	1.62	-	-	1.65	-	-	7.85	-	-	9.50	-	-	
101-1	72 hr.	1.03	-	-	1.65	-	-	3.05	-	-	4.70	-	-	
102-2	28 hr.	2.08	-	-	2.75	-	-	6.15	-	-	8.90	-	-	
103-1	18 hr.	2.42	3.22	-	2.65	3.55	-	3.25	2.85	-	5.90	6.40	-	
105-2	0 hr.	1.67	-	-	1.95	-	-	3.75	-	-	5.70	-	-	
106-1	15 hr.	0.61	1.09	-	0.70	1.05	-	2.80	3.35	-	3.50	4.40	-	

' Time of treatment after calving. Minus sign indicates time before calving.

" Time of third sample after treatment.

* Mgms. P./100 ml. Plasma.

Plasma Phosphates Before and After Treatment, for Cases of Milk Fever that did not Respond Satisfactorily to Calcium Therapy.

Cow No. & Treat. No.	Time' of Treat.	Inorganic P.*			Total Acid Sol.P.*			Lipid P.*			Total P.*			Time of Sample III."
		Before Treat.	¼-½ hr.	Sample III.	Before Treat.	¼-½ hr.	Sample III.	Before Treat.	¼-½ hr.	Sample III.	Before Treat.	¼-½ hr.	Sample III.	
34-1	4 hr.	0.80	1.15	-	1.45	1.50	-	1.50	1.70	-	4.40	4.40	-	
38-1	6 hr.	1.20	2.40	-	2.05	3.05	-	3.20	3.20	-	5.10	6.50	-	
44-3	36 hr.	3.70	4.25	4.10	6.50	6.90	7.10	5.60	4.80	5.50	9.40	10.10	10.00	6 hr.
47-1	-2 hr.	2.35	3.10	4.15	4.30	4.70	6.05	3.60	4.30	3.80	6.40	8.00	9.20	6 hr.
48-1	7 hr.	0.50	1.20	1.15	1.10	1.70	1.95	2.90	2.90	3.10	4.10	4.70	4.90	5 hr.
51-1	7 hr.	0.45	0.45	2.85	1.65	1.40	3.90	4.10	3.80	4.20	5.20	4.50	7.30	18 hr.
60-1	12 hr.	0.80	1.60	1.20	0.80	1.45	1.65	2.70	2.20	2.70	3.70	3.70	4.60	15 hr.
60-2	30 hr.	1.20	3.00	-	1.65	3.30	-	2.70	3.70	-	4.60	5.50	-	
82-1	-3 hr.	2.12	2.12	2.08	3.20	3.55	3.25	2.60	2.85	3.15	5.80	6.40	6.40	1 hr.
85-2	32 hr.	1.11	-	2.08	1.50	-	3.05	3.50	-	4.40	5.00	-	6.45	1 hr.
92-2	11 hr.	2.99	3.92	3.92	3.35	4.20	4.40	3.15	3.10	3.40	6.50	7.30	7.80	5 hr.
93-1	8 hr.	2.71	4.26	-	2.70	4.65	-	3.50	3.15	-	6.20	7.80	-	
98-1	16 hr.	1.15	1.50	-	1.50	1.75	-	2.60	2.75	-	4.10	4.50	-	
99-1	8 hr.	0.55	0.92	0.83	0.80	1.00	1.10	2.10	2.20	2.30	2.90	3.20	3.40	4 hr.
102-1	12 hr.	0.74	0.83	-	1.25	1.25	-	2.65	2.65	-	3.90	3.90	-	
105-1	-6 hr.	1.33	1.50	1.67	1.55	1.70	1.95	3.85	3.40	3.75	5.40	5.10	5.70	6 hr.

' Time of Treatment after calving. Minus sign indicates time before calving.
" Time of third sample after treatment.
* Mgms. P./100 ml. Plasma.

TABLE

Calcium/Inorganic Phosphate Ratios in Milk Fever Cases, treated with Calcium Borogluconate.

Satisfactory Response.

Cow & Treat. Nos.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
29-1	5.45	-	6.70	5.52	4.53	2.16	-	2.55
31-2	2.23	-	3.64	3.29	2.37	-	0.86	-
36-1	2.31	5.33	-	3.76	2.65	1.59	-	1.66
63-1	9.76	-	6.00	3.52	-	2.85	-	2.62
85-3	3.10	-	3.03	-	-	2.08	8.83	1.59
92-3	2.25	3.67	2.93	-	-	-	2.09	2.67
66-2	2.48	4.79"	4.87	3.74	2.87	2.91	2.98	1.97
88-1	10.70	8.74	9.89	7.53	7.15	8.57	4.17	1.72
94-1	2.28	3.72	3.62	3.64	3.07	2.58	1.82	1.39
96-1	2.02	3.36	2.92	2.29	1.82	1.52	1.76	1.25
111-1	3.68	6.72	5.11	4.83	7.04	3.18	3.36	1.95

Unsatisfactory Response.

Cow & Treat. Nos.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-2	10.40	-	18.30	13.40	8.63	-	8.72	-
44-1	5.15	8.00	-	5.37	-	6.46	5.61	-
61-1	5.83	7.11	-	5.23	3.95	-	4.48	2.42
62-1	6.70	8.25	-	5.28	-	-	3.07	-
65-1	2.67	7.23	-	-	-	3.57	2.92	-
85-1	3.08	5.68	-	-	-	3.77	5.82	3.72
89-1	4.78	7.30	6.26	-	7.15	4.00	-	4.01
31-1	3.17	11.85	7.28	4.86	3.46	3.18	3.84	2.42
32-1	4.86	21.60	14.90	11.79	9.93	11.35"	16.65	10.40
81-1	2.32	4.90	5.75	3.15	2.23	3.14	2.74	2.13
84-1	5.07	6.55	5.75	3.72	4.66	3.63	3.00	7.00
92-1	6.10	14.55	8.64	6.62	4.67	4.36	3.93	2.61

" Calculated according to Snedecor (90).

Calcium/Total Acid Soluble Phosphate Ratios in Milk Fever Cases, treated with Calcium Borogluconate.

Satisfactory Response.

Cow & Treat. Nos.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
29-1	3.12	-	6.11	4.85	4.16	1.79	-	1.56
31-2	1.29	-	2.45	2.03	1.44	-	0.64	-
36-1	1.80	4.48	2.96	2.50	-	1.56	-	1.51
63-1	1.66	-	3.42	2.47	-	1.63	-	1.41
85-3	1.11	-	2.15	-	-	1.36	1.16	1.10
92-3	1.94	3.27	2.67	-	-	-	2.06	2.27
66-2	1.67	5.80"	3.48	3.00	2.20	1.97	1.97	1.47
88-1	12.40	15.40	13.50	7.00	5.72	2.36	1.92	1.56
94-1	2.28	3.72	3.62	3.80	2.76	2.66	1.79	1.29
96-1	1.86	2.86	2.64	2.18	1.67	1.43	1.66	1.21
111-1	2.80	6.80	5.11	4.71	6.26	2.92	2.90	1.97

Unsatisfactory Response.

Cow & Treat. Nos.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-2	4.06	-	19.83	16.73	8.34	-	4.25	-
44-1	3.23	5.08	-	3.74	-	3.49	3.16	-
61-1	2.69	6.16	-	3.79	2.95	-	4.04	1.83
62-1	6.00	5.08	-	3.71	-	-	2.50	-
65-1	2.08	5.48	-	-	-	2.81	2.28	-
85-1	1.59	3.38	-	-	-	2.57	2.26	2.38
89-1	2.91	6.70	5.63	-	5.23	3.48	-	2.37
31-1	2.41	11.90	4.76	3.76	3.66	2.34	2.14	1.76
32-1	1.62	11.50	7.90	5.75	7.10	5.18"	5.78	4.06
81-1	1.79	3.18	2.97	2.45	1.96	2.08	1.62	1.21
84-1	2.96	4.37	4.05	3.12	2.37	2.19	1.93	5.30
92-1	3.92	6.91	5.89	4.82	3.65	3.40	3.06	2.07

" Calculated according to Snedecor (90).

Calcium/Total Phosphate Ratios in Milk Fever Cases, treated with Calcium Borogluconate.

Satisfactory Response.

Cow & Treat. Nos.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
29-1	0.53	-	1.57	1.25	1.28	0.77	-	0.86
31-2	0.76	-	1.71	1.43	1.20	-	0.45	-
36-1	0.53	2.06	-	1.42	1.21	0.71	-	0.80
63-1	0.73	-	1.71	1.28	-	0.90	-	0.74
85-3	0.67	-	1.39	-	-	0.83	0.76	0.68
92-3	0.77	1.70	1.37	-	-	-	1.00	1.10
66-2	0.51	1.52"	1.25	1.11	0.95	0.86	0.82	0.75
88-1	1.03	1.13	1.35	1.33	1.39	1.15	1.10	0.85
94-1	0.76	1.90	1.74	1.45	1.05	1.22	1.02	0.76
96-1	0.68	1.72	1.49	1.25	1.04	0.86	0.90	0.69
111-1	0.67	2.21	1.80	1.58	1.46	1.02	1.00	0.43

Unsatisfactory Response.

Cow & Treat. Nos.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-2	1.80	-	4.25	3.46	3.83	-	2.62	-
44-1	0.72	1.49	-	1.05	-	0.85	0.78	-
61-1	0.92	2.30	-	1.71	1.62	-	1.51	1.10
62-1	1.72	3.00	-	2.12	-	-	1.88	-
65-1	0.79	2.37	-	-	-	1.12	1.00	-
85-1	0.76	1.87	-	-	-	1.37	1.26	1.17
89-1	1.80	3.71	3.38	-	2.76	2.16	-	1.14
31-1	0.74	3.78	2.48	2.04	1.35	1.08	1.08	0.71
32-1	0.81	5.25	3.52	3.43	2.55	2.53"	2.22	1.80
81-1	0.72	1.69	1.54	1.31	1.08	1.07	0.90	0.66
84-1	0.53	1.44	1.17	0.96	0.85	0.83	0.84	0.75
92-1	1.47	2.99	2.50	1.99	1.75	1.66	1.61	1.14

" Calculated according to Snedecor (90).

Plasma Phosphates in Milk Fever Cases, treated by Udder Inflation.

Inorganic Phosphate.*

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
34-2	5 h.	1.40	-	2.10	-	-	-	4.00	-
44-2"	20 h.	0.90	1.20	1.40	-	3.05	-	2.80	-
44-4	60 h.	0.95	2.20	2.10	-	3.00	-	2.00	3.50
49-1	12 h.	1.40	-	2.10	-	-	5.30	-	-
81-2	12 h.	1.07	-	0.78	-	1.91	2.84	-	4.10
82-2	0 h.	2.08	-	-	2.82	-	1.59	2.00	2.45
99-2	12 h.	0.83	1.39	-	-	-	-	-	-
32-3	16 h.	0.90	1.25	1.75	2.30	3.06L	3.00	3.20	4.50
80-1	7 h.	1.28	2.11	2.28	2.32	2.82	3.76	3.24	2.44
89-2	12 h.	0.19	1.15	2.20	0.04	3.26	5.96	1.50	6.58
90-1"'	-8 h.	0.86	1.34	1.65	2.86	3.54	3.84	2.67	2.43
104-1	12 h.	0.45	0.79	1.11	1.61	2.26	2.72	3.58	4.19

Total Acid Soluble Phosphate.*

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
34-2	5 h.	1.70	-	2.70	-	-	-	4.90	-
44-2"	20 h.	1.60	2.70	2.75	-	5.10	-	5.45	-
44-4	60 h.	3.90	3.75	4.30	-	5.60	-	4.20	6.05
49-1	12 h.	1.95	-	2.90	-	-	5.95	-	-
81-2	12 h.	1.90	-	1.95	-	2.80	3.70	-	5.45
82-2	0 h.	3.25	-	-	5.30	-	4.45	4.15	3.80
99-2	12 h.	1.10	1.75	-	-	-	-	-	-
32-3	16 h.	1.85	1.20	1.65	2.35	3.46L	2.90	3.10	4.85
80-1	7 h.	1.60	2.50	2.90	3.45	3.75	4.30	4.10	3.75
89-2	12 h.	0.60	1.85	3.35	5.70	5.50	6.60	5.90	6.58
90-1"'	-8 h.	1.65	1.65	2.15	3.60	4.45	4.70	3.20	3.05
104-1	12 h.	0.60	0.95	1.35	1.70	2.65	3.10	3.90	4.50

' Time of treatment after calving (hours). Minus sign indicates time before calving.

" Relapsed.

"' Failed to respond. Died after further treatment.

L Calculated according to Snedecor (90).

* Mgms. P./100 ml. Plasma.

Plasma Phosphates in Milk Fever Cases, treated by Udder Inflation.

Lipid Phosphate.*

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
34-2	5 h.	1.70	-	2.80	-	-	-	2.60	-
44-2"	20 h.	5.10	6.10	5.90	-	5.10	-	3.80	-
44-4	60 h.	5.00	5.40	5.70	-	5.70	-	5.90	4.40
49-1	12 h.	3.70	-	4.50	-	-	4.10	-	-
81-2	12 h.	5.10	-	4.65	-	4.40	4.60	-	4.05
82-2	0 h.	3.15	-	-	2.70	-	2.85	3.05	2.80
99-2	12 h.	2.30	2.25	-	-	-	-	-	-
32-3	16 h.	2.70	2.50	3.20	3.30	3.03⊥	3.60	3.80	3.20
80-1	7 h.	2.30	2.70	2.00	2.15	2.35	2.30	2.40	2.45
89-2	12 h.	1.70	1.85	1.95	1.50	1.40	1.40	1.70	2.42
90-1"'	-8 h.	1.55	2.05	2.05	1.20	1.75	2.00	2.80	1.95
104-1	12 h.	3.30	3.55	3.65	4.00	3.35	3.00	3.10	3.40

Total Phosphate.*

Cow & Treat. Nos.	Time' of Treat.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
34-2	5 h.	4.40	-	6.00	-	-	-	8.10	-
44-2"	20 h.	6.50	7.80	8.40	-	8.80	-	8.50	-
44-4	60 h.	8.20	8.10	8.20	-	10.10	-	8.80	10.70
49-1	12 h.	5.60	-	7.20	-	-	10.00	-	-
81-2	12 h.	7.00	-	6.60	-	7.20	8.30	-	9.50
82-2	0 h.	6.40	-	-	8.00	-	7.30	7.20	6.60
99-2	12 h.	2.90	3.20	-	-	-	-	-	-
32-3	16 h.	3.00	3.30	5.70	6.20	6.51⊥	6.90	7.10	8.20
80-1	7 h.	3.90	5.20	4.90	5.60	6.10	6.60	6.50	6.20
89-2	12 h.	2.30	3.70	5.30	7.20	6.90	8.00	7.60	9.00
90-1"'	-8 h.	3.20	3.70	4.20	4.80	6.20	6.70	6.00	5.00
104-1	12 h.	3.90	4.50	5.00	5.70	6.00	6.10	7.00	7.90

' Time of treatment after calving (hours). Minus sign indicates time before calving.

" Relapsed.

"' Failed to respond. Died after further treatment.

⊥ Calculated according to Snedecor (90).

* Mgms. P./100 ml. Plasma.

Calcium/Phosphate Ratios in Milk Fever Cases, treated by Udder Inflation.

Calcium/Inorganic Phosphate Ratios.

Cow & Treat. Nos.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-3	8.71	6.61	5.22	3.94	-3.76'	3.14	2.97	1.78
80-1	5.08	3.86	3.42	3.45	2.87	2.21	2.72	3.77
89-2	20.00	4.26	2.78	205.00	2.52	1.36	4.87	0.97
90-1	5.70	3.81	3.16	2.03	1.67	1.58	-5.27'	2.34
104-1	7.76	6.00	4.50	3.67	3.02	2.50	1.97	1.78

Calcium/Total Acid Soluble Phosphate Ratios.

Cow & Treat. Nos.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-3	4.26	6.89	5.54	3.86	3.37'	3.25	3.06	1.65
80-1	4.07	3.24	2.69	2.32	2.16	1.93	2.15	2.46
89-2	6.33	2.65	1.82	1.44	1.49	1.24	1.24	0.97
90-1	2.97	3.09	2.42	1.61	1.32	1.29	1.00'	1.87
104-1	5.83	5.00	3.71	3.47	2.57	2.19	1.81	1.65

Calcium/Total Phosphate Ratios.

Cow & Treat. Nos.	Before Treat.	Time after Treatment 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
32-3	2.62	2.51	1.65	1.46	1.65'	1.37	1.33	0.98
80-1	1.67	1.56	1.59	1.43	1.33	1.26	1.35	1.48
89-2	1.65	1.32	1.15	1.14	1.19	1.02	0.96	0.71
90-1	1.53	1.38	1.24	1.21	0.95	0.90	1.00'	1.14
104-1	0.90	1.06	1.00	1.03	1.13	1.11	1.01	0.94

' Calculated according to Snedecor (90).

Plasma Phosphate Levels in Normal Cows, injected with Calcium Borogluconate.

Inorganic Phosphate.*

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B38.	6.03	6.00	6.03	5.70	4.81	4.84	4.58	5.00
B14.	3.92	4.06	5.53	5.31	3.71	3.92	4.16	3.97
B24.	4.79	5.75	5.37	5.09	4.90	3.71	5.62	5.68
B 9.	4.26	5.12	5.72	6.17	5.11	3.75	4.03	5.62
C 0.	3.04	2.10	1.49	3.54	4.56	3.92	2.18	5.13
B33.	1.23	1.55	1.36	1.40	3.30	3.50	3.07	1.65

Parturient Cows.

Cow No.	Before Inject.	Time after Injection 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 7.	1.29	3.97	4.56	2.10	2.80	2.36	3.07	3.41
B 6.	2.21	2.90	2.82	3.86	4.00	5.40	3.04	2.35
B 4.	6.14	7.62	8.26	8.77	6.92	5.42	4.66	5.02
B20.	3.56	4.25	4.95	5.31	5.81	5.04	4.09	3.45
B19.	3.54	3.92	4.06	4.66	5.13	3.41	4.00	3.10
B19.	3.38	4.75	5.22	5.47	3.13	3.10	2.32	1.24

Total Acid Soluble Phosphate.*

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B38.	6.55	6.30	6.40	6.30	5.95	6.00	5.55	5.65
B14.	4.60	6.10	6.45	6.20	5.35	4.80	5.00	4.95
B24.	5.75	6.60	6.35	6.70	6.10	5.75	6.45	7.15
B 9.	6.20	6.80	6.65	6.95	6.35	4.75	4.45	6.05
C 0.	6.45	6.45	6.40	6.40	6.95	6.35	5.75	6.30
B33.	5.10	5.30	5.55	6.50	6.10	5.10	4.95	4.65

Parturient Cows.

Cow No.	Before Inject.	Time after Injection 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 7.	5.50	5.70	5.70	4.75	4.55	3.65	3.75	4.25
B 6.	3.40	3.75	4.00	5.40	5.10	6.90	5.75	5.40
B 4.	6.40	8.45	8.95	9.20	7.60	5.80	5.10	5.70
B20.	4.20	5.05	5.90	6.30	6.60	5.55	4.65	4.00
B19.	3.75	4.35	4.40	5.10	5.40	3.70	4.05	3.45
B19.	4.05	5.80	6.20	5.95	5.30	4.00	3.00	3.95

Underlined values are those considered to show the maximum change initiated by Calcium Injection.

* Mgms. P./100 ml. Plasma.

Plasma Phosphate Levels in Normal Cows, injected with Calcium Borogluconate.

Lipid Phosphate.*

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B38.	8.65	7.70	7.80	7.50	7.75	7.60	7.85	7.75
B14.	6.30	5.70	5.75	5.80	6.15	6.30	6.40	6.45
B24.	5.05	4.70	4.70	4.00	4.70	4.30	4.20	4.30
B 9.	7.00	6.80	7.15	7.05	6.45	6.45	6.65	6.85
C 0.	3.35	4.05	3.40	4.30	3.35	3.15	3.45	3.40
B33.	3.70	3.70	3.75	2.80	3.30	3.10	2.85	3.05

Parturient Cows.

Cow No.	Before Inject.	Time after Injection 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 7.	9.50	9.10	9.30	9.45	9.05	8.55	8.45	8.15
B 6.	2.20	1.85	2.10	1.40	1.90	1.90	2.75	2.40
B 4.	3.40	3.20	3.30	3.30	3.20	3.30	3.40	3.60
B20.	4.20	4.00	4.10	4.30	4.30	4.70	4.60	4.80
B19.	2.95	3.05	3.30	3.30	3.50	4.10	3.75	4.05
B19.	4.25	4.20	4.50	4.65	4.20	3.50	3.90	3.55

Total Phosphate.*

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B38.	15.20	14.00	14.20	13.80	13.70	13.60	13.40	13.40
B14.	10.90	11.80	12.20	12.00	11.50	11.10	11.40	11.40
B24.	10.70	11.10	10.60	10.90	10.20	9.60	10.10	10.50
B 9.	13.20	13.60	13.80	14.00	12.80	11.20	11.10	12.90
C 0.	9.80	10.50	9.80	10.70	10.20	9.50	9.20	9.90
B33.	8.80	9.00	9.30	9.30	9.40	8.20	7.80	7.70

Parturient Cows.

Cow No.	Before Inject.	Time after Injection 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 7.	15.00	14.80	15.00	14.20	13.60	12.20	12.20	12.40
B 6.	5.60	5.60	6.10	6.80	7.00	8.80	8.50	7.80
B 4.	9.20	10.00	10.70	11.80	10.00	8.40	7.50	8.60
B20.	7.20	7.90	8.30	9.10	9.60	8.80	8.00	7.80
B19.	6.70	7.40	7.70	8.40	8.90	7.80	7.80	7.50
B19.	8.30	10.00	10.70	10.60	9.50	7.50	6.90	7.50

Underlined values are those considered to show the maximum change initiated by Calcium Injection.

* Mgms. P./100 ml. Plasma.

Calcium/Phosphate Ratios in Normal Cows, injected with Calcium Borogluconate.

Calcium/Inorganic Phosphate Ratios.

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B38.	1.74	3.16	2.90	2.97	2.76	2.40	2.27	2.12
B14.	2.86	4.52	2.89	2.60	3.39	2.76	2.65	2.59
B24.	2.44	3.58	3.36	3.11	2.72	3.15	1.88	1.86
B 9.	2.57	4.01	3.18	2.51	2.64	3.17	2.85	1.96
C 0.	3.36	8.58	10.90	4.16	3.00	3.11	5.22	2.10
B33.	9.31	10.32	11.33	10.45	4.25	3.92	4.08	7.50

Parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 7.	8.38	5.01	4.02	8.00	5.72	5.55	3.82	3.18
B 6.	3.76	4.38	4.27	2.98	2.75	2.04	3.22	3.71
B 4.	1.45	2.34	2.07	1.79	1.85	2.14	2.27	1.88
B20.	2.72	4.08	3.15	2.71	2.32	2.36	2.54	2.61
B19.	2.77	4.91	4.34	3.39	2.63	3.37	2.58	3.25
B19.	3.16	3.76	2.98	2.67	4.18	3.78	4.65	7.73

Calcium/Total Acid Soluble Phosphate Ratios.

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B38.	1.59	3.02	2.73	2.18	2.23	1.93	1.87	1.88
B14.	2.43	3.02	2.48	2.23	2.36	2.25	2.20	2.08
B24.	2.03	3.14	2.85	2.36	2.18	2.03	1.64	1.48
B 9.	1.76	3.02	2.73	2.23	2.13	2.50	2.58	1.82
C 0.	1.58	2.78	2.53	2.30	1.97	1.92	1.98	1.72
B33.	2.25	3.02	2.78	2.25	2.29	2.69	2.52	2.67

Parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 7.	1.96	3.50	3.22	3.54	3.51	3.58	3.12	2.55
B 6.	2.44	3.39	3.00	2.13	2.16	1.59	1.70	1.61
B 4.	1.39	2.11	1.90	1.70	1.68	2.00	2.08	1.66
B20.	2.30	3.44	2.65	2.28	2.04	2.14	2.23	2.25
B19.	2.62	4.42	4.00	3.11	2.50	3.11	2.54	2.92
B19.	2.65	3.07	2.52	2.46	2.47	2.93	3.60	2.44

Calcium/Phosphate Ratios in Normal Cows, injected with Calcium Borogluconate.

Calcium/Total Phosphate Ratios.

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B38.	0.69	1.36	1.23	1.22	0.97	0.85	0.78	0.79
B14.	1.03	1.56	1.31	1.15	1.10	0.97	0.96	0.90
B24.	1.09	1.86	1.71	1.45	1.30	1.22	1.04	1.05
B 9.	0.83	1.50	1.32	1.11	1.06	1.06	1.04	0.85
C 0.	1.04	1.72	1.63	1.38	1.34	1.28	1.24	1.09
B33.	1.30	1.78	1.65	1.57	1.49	1.67	1.60	1.61

Parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 7.	0.74	1.34	1.22	1.18	1.17	1.07	0.96	0.87
B 6.	1.48	2.27	1.97	1.69	1.59	1.25	1.15	1.12
B 4.	0.97	1.78	1.59	1.33	1.28	1.38	1.41	1.10
B20.	1.34	2.20	1.88	1.58	1.41	1.35	1.30	1.15
B19.	1.46	2.60	2.28	1.88	1.52	1.47	1.32	1.34
B19.	1.29	1.78	1.46	1.38	1.38	1.56	1.58	1.28

Plasma Phosphate Levels in Normal Cows, injected with Acid Sodium Phosphate.

Inorganic Phosphate.*

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 4.	5.09	17.50	14.05	11.24	7.62	6.92	6.79	5.48
B 9.	4.15	14.00	11.75	9.63	7.54	6.18	6.44	7.27
B11.	5.66	14.70	11.93	8.78	6.66	6.62	5.44	5.70
B20.	5.88	15.15	14.25	12.10	9.32	7.18	6.24	5.22
B23.	5.07	13.35	10.45	7.80	4.75	4.85	3.70	4.48
BH8.	5.18	15.13	13.83	10.54	7.79	6.35	5.70	5.03

Parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	4.21	15.13	13.50	10.36	9.50	7.09	6.22	4.55
B 6.	4.77	14.68	13.33	11.25	8.99	7.45	6.72	6.14
B14.	1.55	8.77	8.14	6.22	4.28	3.68	3.66	3.58
B.C.	3.72	12.80	11.95	10.75	7.84	6.84	6.05	5.82
BH8.	3.71	14.25	12.60	11.00	8.05	5.48	5.48	5.82
B37.	3.07	11.65	10.45	8.90	6.14	5.28	4.96	3.80

Total Acid Soluble Phosphate.*

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 4.	5.20	17.65	14.00	11.20	7.85	7.15	7.00	5.50
B 9.	5.90	15.00	12.50	10.00	8.25	7.35	7.60	7.85
B11.	6.05	14.35	11.50	8.65	6.75	6.65	5.55	5.75
B20.	6.30	15.20	14.40	12.10	9.60	7.30	6.45	5.25
B23.	5.85	19.25	15.00	13.25	7.90	6.00	4.80	5.90
BH8.	5.50	15.40	13.80	12.10	8.35	6.60	6.20	5.30

Parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	4.55	15.20	13.90	12.10	10.40	7.65	6.90	4.75
B 6.	5.10	16.17	14.50	12.17	9.55	8.15	6.90	6.50
B14.	1.65	10.50	8.70	6.50	5.10	3.95	4.10	3.95
B.C.	3.95	13.20	12.20	11.20	8.40	7.35	6.90	6.45
BH8.	4.75	15.10	14.45	11.75	9.25	7.15	6.70	6.55
B37.	3.20	11.65	10.13	9.38	6.45	5.15	4.95	3.80

* Mgms. P./100 ml. Plasma.

Plasma Phosphate Levels in Normal Cows, injected with Acid Sodium Phosphate.

Lipid Phosphate.*

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 4.	6.50	5.35	5.90	6.40	5.65	6.25	6.40	6.90
B 9.	8.60	7.60	9.50	9.20	9.35	7.85	8.70	8.55
B11.	7.35	8.45	8.50	7.85	8.85	7.35	8.35	6.95
B20.	4.60	4.20	3.20	3.70	4.20	4.30	3.55	4.75
B23.	5.80	5.60	5.60	5.50	5.60	5.60	5.00	5.60
BH8.	4.90	4.90	5.00	5.20	4.55	5.00	4.70	4.80

Parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	6.15	4.80	5.30	5.70	4.70	5.15	5.10	5.55
B 6.	2.20	0.00	0.00	0.53	1.15	1.75	1.70	1.80
B14.	3.25	2.10	2.80	2.80	2.40	2.65	2.90	3.15
B37.	1.30	0.75	1.35	0.92	1.75	1.35	1.85	1.80
B.C.	3.15	3.10	3.10	2.90	4.00	2.65	2.60	3.65
BH8.	3.25	1.90	2.15	2.15	2.75	3.55	2.60	2.65

Total Phosphate.*

Non-parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 4.	11.70	23.00	19.90	17.60	13.50	13.40	13.40	12.40
B 9.	14.50	22.60	21.00	19.20	17.60	15.20	16.30	16.40
B11.	13.40	22.80	20.00	16.50	15.60	14.00	13.90	12.70
B20.	10.90	19.40	17.60	15.80	13.80	11.60	10.00	10.00
B23.	11.60	20.30	18.80	16.20	12.30	12.40	10.80	11.40
BH8.	10.40	20.30	18.80	17.30	12.90	11.60	10.90	10.10

Parturient Cows.

Cow No.	Before Inject.	Time after Injection. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	10.70	20.00	19.20	17.80	15.10	12.80	12.00	10.30
B 6.	7.30	15.80	14.50	12.70	10.70	9.90	8.60	8.30
B14.	4.90	12.60	11.60	9.30	7.50	6.60	7.00	7.10
B37.	4.50	12.40	11.50	10.30	8.20	6.50	6.80	5.60
B.C.	7.10	16.30	15.30	14.10	12.40	10.00	9.50	10.00
BH8.	8.00	17.00	16.60	13.90	12.00	10.70	9.30	9.20

* Mgms. P./100 ml. Plasma.

Inorganic Phosphate Levels in Normal Cows, after Udder Inflation.*

Non-parturient Cows - Non-lactating.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	5.90	6.40	6.38	5.78	5.27	4.78	5.20	5.58
B 6.	5.48	6.25	7.04	6.66	6.58	5.78	5.92	5.57
BH8.	5.78	5.88	5.70	5.70	5.40	4.63	5.04	5.53
B27.	5.06	5.88	6.22	6.22	6.22	5.36	4.06	5.08

Non-parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B10.	6.79	6.88	6.26	6.58	6.05	5.44	5.96	6.14
B14.	4.50	5.58	5.62	5.56	6.12	4.96	4.48	4.92
B27.	5.85	5.53	5.58	6.40	6.22	6.76	6.75	6.14
B33.	4.33	5.22	5.44	5.96	6.05	5.82	5.43	3.84

Non-parturient Cows - Lactating, not milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B17.	6.35	7.14	6.75	6.49	7.00	6.64	6.78	6.22
B21.	6.96	7.96	7.83	8.39	7.70	7.70	8.90	9.16
B34.	3.97	5.21	6.22	5.57	5.44	6.09	6.49	7.27
B37.	5.02	6.49	6.29	6.79	6.52	6.30	6.60	7.88

Parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B37.	2.41	2.90	3.02	3.46	3.77	3.86	5.18	4.42
B13.	2.23	4.19	4.10	4.55	5.22	5.65	5.99	6.54
B 5.	2.71	3.77	4.10	5.12	5.70	6.61	7.58	8.73
B34.	1.52	4.45	1.24	1.89	1.23	0.23	2.60	2.06
B17.	0.12	2.60	0.46	2.01	1.48	1.69	3.41	2.14
B33.	1.99	2.44	3.94	4.09	4.33	4.58	4.39	1.73

* Mgms. P./100 ml. Plasma.

Total Acid Soluble Phosphate Levels in Normal Cows, after Udder Inflation.*

Non-parturient Cows - Non-lactating.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	6.35	7.00	6.80	6.20	6.05	5.25	5.45	5.90
B 6.	5.60	6.55	7.25	6.55	6.95	5.75	5.90	5.70
BH8.	6.70	6.75	6.25	6.25	5.75	5.40	5.60	5.90
B27.	5.05	6.20	6.25	6.25	6.25	5.35	4.00	5.30

Non-parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B10.	6.75	6.90	6.50	6.50	6.20	5.75	5.95	6.05
B14.	4.45	5.90	5.90	5.80	6.10	5.15	4.50	4.75
B27.	6.25	5.90	5.90	6.85	6.45	6.70	6.85	6.30
B33.	4.60	5.85	6.00	6.40	6.20	6.00	5.75	4.20

Non-parturient Cows - Lactating, not milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B17.	6.50	7.50	7.20	6.45	7.25	6.85	6.95	6.35
B21.	7.50	8.50	8.25	8.75	8.60	8.15	9.50	9.25
B34.	4.15	5.30	6.35	5.65	5.70	6.25	6.80	7.45
B37.	4.60	6.50	6.35	6.85	6.80	6.35	6.60	7.60

Parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B37.	2.55	3.10	3.30	3.85	3.90	5.00	5.45	5.85
B13.	2.40	4.70	4.55	5.35	5.85	6.55	6.50	6.75
B 5.	2.80	4.40	4.70	5.50	6.25	6.80	8.10	9.10
B34.	3.95	5.05	5.05	5.40	6.00	5.85	6.35	6.25
B17.	4.40	5.40	5.20	5.35	5.75	5.40	4.75	4.85
B33.	3.10	4.30	4.20	4.30	4.85	4.95	4.65	5.45

* Mgms. P./100 ml. Plasma.

Lipid Phosphate Levels in Normal Cows, after Udder Inflation.*

Non-parturient Cows - Non-lactating.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	4.15	4.10	4.80	5.00	3.95	3.85	3.05	4.10
B 6.	6.00	5.65	5.85	5.65	4.85	5.45	4.80	4.50
BH8.	4.00	4.05	4.45	4.35	4.35	2.50	2.90	4.40
B27.	4.85	3.90	4.45	3.35	3.45	2.65	3.10	3.80

Non-parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B10.	5.25	5.80	5.40	5.60	5.80	5.65	4.65	6.05
B14.	5.45	5.00	4.80	5.10	5.10	4.35	4.30	4.95
B27.	11.25	11.70	11.60	10.55	10.05	8.70	8.55	9.50
B33.	7.60	7.75	6.90	6.50	6.40	5.80	5.85	7.10

Non-parturient Cows - Lactating, not milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B17.	6.20	5.60	5.60	5.45	4.65	4.65	4.65	4.75
B21.	8.80	9.50	9.95	10.15	9.90	9.75	9.00	9.25
B34.	8.25	8.60	8.35	8.55	8.00	6.85	7.30	7.35
B37.	6.30	5.90	6.05	5.85	5.70	5.55	5.40	6.00

Parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B37.	2.65	2.50	3.00	3.30	2.50	2.50	2.35	2.55
B13.	4.00	3.50	4.95	3.95	3.65	3.05	3.70	4.75
B 5.	3.40	2.40	2.40	2.90	2.85	2.90	2.20	3.30
B34.	2.05	1.15	1.55	1.40	1.40	2.05	2.55	2.75
B17.	3.00	2.70	2.80	3.15	2.45	2.80	3.75	3.25
B33.	3.60	3.00	2.90	3.20	2.65	3.35	3.15	3.55

* Mgms. P./100 ml. Plasma.

Total Phosphate Levels in Normal Cows, after Udder Inflation.*

Non-parturient Cows - Non-lactating.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	10.50	11.10	11.60	11.20	10.00	9.10	8.50	10.00
B 6.	11.60	12.20	13.10	12.20	11.80	11.20	10.70	10.20
BH8.	10.70	10.80	10.70	10.60	10.10	7.90	8.50	10.30
B27.	9.90	10.10	10.70	9.60	9.70	8.00	7.10	8.10

Non-parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B10.	12.00	12.70	11.90	12.10	12.00	11.40	10.60	12.10
B14.	9.90	10.90	10.70	10.90	11.20	9.50	8.80	9.70
B27.	17.50	17.60	17.50	17.40	16.50	15.40	15.40	15.80
B33.	12.20	13.60	12.90	12.90	12.60	11.80	11.60	11.30

Non-parturient Cows - Lactating, not milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B17.	12.70	13.10	12.80	11.90	11.90	11.50	11.60	11.10
B21.	16.30	18.00	18.20	18.90	18.50	17.90	18.50	18.50
B34.	12.40	13.90	14.70	14.20	13.70	13.10	14.10	14.80
B37.	10.90	12.40	12.40	12.70	12.50	11.90	12.00	13.60

Parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B37.	5.20	5.60	6.30	6.50	6.40	7.50	7.80	8.40
B13.	6.40	8.20	9.50	9.30	9.50	9.60	10.20	11.50
B 5.	6.20	6.80	7.10	8.40	9.10	9.70	10.30	12.40
B34.	6.00	6.20	6.60	6.80	7.40	7.90	8.90	9.00
B17.	7.40	8.10	8.00	8.50	8.20	8.20	8.50	8.10
B33.	6.70	7.30	7.10	7.50	7.50	8.30	7.80	9.00

* Mgms. P./100 ml. Plasma.

Calcium/Inorganic Phosphate Ratios in Normal Cows, after Udder Inflation.

Non-parturient Cows - Non-lactating.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	1.61	1.55	1.53	1.52	1.69	1.86	1.70	1.74
B 6.	1.83	1.56	1.37	1.30	1.40	1.56	1.51	1.66
BH8.	1.85	1.75'	1.75	1.49	1.70	2.05	1.90	1.67
B27.	2.31	1.90	1.82	1.62	1.61	1.77	2.23	1.91

Non-parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B10.	1.64	1.65	1.71	1.61	1.79	1.92	1.78	1.69
B14.	2.18	1.81	1.90	1.86	1.70	1.88	1.96	2.08
B27.	1.76	1.95	1.95	1.78	1.68	1.37	1.49	1.64
B33.	2.19	1.92	1.84	1.68	1.64	1.64	1.83	2.62

Non-parturient Cows - Lactating, not milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B17.	1.64	1.57	1.57	1.52	1.40	1.46	1.44	1.61
B21.	1.41	1.37	1.40	1.37	1.43	1.47	1.12	1.02
B34.	2.61	1.98	1.61	1.92	1.89	1.69	1.51	1.39
B37.	2.01	1.69	1.72	1.60	1.71	1.70	1.64	1.36

Parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B37.	3.71	3.12	3.21	2.84	2.38	2.55	1.93	2.27
B13.	4.36	2.52	2.64	2.46	2.18	1.90	1.93	1.54
B 5.	2.88	2.26	2.38	1.95	1.84	1.47	1.37	1.03
B34.	5.00	2.08	7.65	5.10	8.05	42.60	3.94	4.57
B17.	82.60	4.04	22.30	5.24	7.40	6.45	3.22	5.10
B33.	4.33	3.73	2.38	2.22	2.39	2.11	2.46	5.85

' Calculated according to Snedecor (90).

Calcium/Total Acid Soluble Phosphate Ratios in Normal Cows, after Udder Inflation.

Non-parturient Cows - Non-lactating.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	1.50	1.42	1.44	1.44	1.48	1.70	1.62	1.64
B 6.	1.79	1.49	1.33	1.27'	1.33	1.56	1.51	1.66
BH8.	1.59	1.61'	1.60	1.36	1.63	2.06	1.90	1.67
B27.	2.31	1.80	1.81	1.62	1.60	1.78	2.27	1.83

Non-parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B10.	1.64	1.64	1.64	1.63	1.75	1.82	1.77	1.72
B14.	2.21	1.71	1.82	1.78	1.71	1.82	1.96	2.15
B27.	1.71	1.83	1.84	1.66	1.60	1.39	1.47	1.60
B33.	2.07	1.71	1.67	1.56	1.60	1.60	1.73	2.39

Non-parturient Cows - Lactating, not milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B17.	1.60	1.49	1.48	1.53	1.35	1.42	1.40	1.57
B21.	1.30	1.28	1.33	1.32	1.28	1.39	1.05	1.01
B34.	2.48	1.94	1.68	1.89	1.81	1.64	1.44	1.36
B37.	2.19	1.69	1.70	1.58	1.64	1.68	1.65	1.41

Parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B37.	3.49	2.92	2.92	2.55	2.31	1.96	1.83	1.71
B13.	4.04	2.24	2.37	2.09	1.90	1.64	1.78	1.50
B 5.	2.78	1.93	2.08	1.82	1.67	1.43	1.28	0.99
B34.	1.92	1.84	1.88	1.82	1.65	1.68	1.61	1.50
B17.	2.31	1.94	1.97	1.96	1.90	2.02	2.31	2.25
B33.	2.78	2.12	2.24	2.12	2.13	1.95	2.32	1.85

' Calculated according to Snedecor (90).

Calcium/Total Phosphate Ratios in Normal Cows, after Udder Inflation.

Non-parturient Cows - Non-lactating.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B 2.	0.91	0.89	0.85	0.79	0.89	0.98	1.04	0.97
B 6.	0.86	0.80	0.74	0.67'	0.78	0.80	0.84	0.91
BH8.	1.00	0.96'	0.93	0.80	0.93	1.20	1.13	0.90
B27.	1.18	1.10	1.06	1.05	1.03	1.19	1.28	1.20

Non-parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B10.	0.93	0.89	0.90	0.87	0.90	0.92	1.00	0.86
B14.	0.99	0.92	1.00	0.95	0.93	0.98	1.00	1.05
B27.	0.59	0.61	0.62	0.65	0.62	0.60	0.65	0.64
B33.	0.78	0.74	0.78	0.77	0.79	0.81	0.86	0.89

Non-parturient Cows - Lactating, not milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B17.	0.82	0.85	0.83	0.83	0.82	0.84	0.84	0.90
B21.	0.60	0.61	0.60	0.61	0.60	0.63	0.54	0.51
B34.	0.83	0.74	0.73	0.75	0.75	0.78	0.69	0.69
B37.	0.93	0.88	0.87	0.85	0.89	0.90	0.91	0.79

Parturient Cows - Lactating, milked out.

Cow No.	Before Inflat.	Time after Inflation. 15 min.	30 min.	1 hr.	2 hrs.	4 hrs.	6 hrs.	10 hrs.
B37.	1.72	1.61	1.54	1.50	1.41	1.31	1.28	1.19
B13.	1.52	1.28	1.14	1.20	1.17	1.12	1.13	0.88
B 5.	1.26	1.25	1.38	1.19	1.15	1.00	1.00	0.73
B34.	1.26	1.50	1.44	1.44	1.34	1.24	1.15	1.04
B17.	1.34	1.30	1.28	1.23	1.33	1.33	1.29	1.34
B33.	1.28	1.24	1.32	1.21	1.38	1.16	1.38	1.12

' Calculated according to Snedecor (90).

Inorganic Phosphate Levels in Pre-partum Milked Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Normal Cows. Number of Calving II. No.B9.	II. No.B14.	IV. No.B29.	V. No.35.	V. No.59.	Milk Fever Cases. Number of Calving V. No.66.	VI. No.31.
37 d.	-	3.77	-	-	-	-	-
34 d.	-	5.36	-	-	-	-	-
31 d.	-	3.65	-	-	-	-	-
26 d.	-	3.58	-	-	-	-	-
18-17 d.	-	1.94	-	4.90	-	-	-
15-14 d.	-	-	-	4.95*	5.00	-	-
13-12 d.	-	-	-	5.40	6.50*	5.10'*	-
11 d.	-	-	-	5.50	-	5.30	-
10 d.	2.84	-	-	5.60	-	5.10	-
9 d.	-	-	-	5.45**	5.05	5.10	-
8 d.	5.30*	-	-	5.40	-	5.30	-
7 d.	-	2.12*	-	4.40	-	5.55	-
6 d.	1.84	-	-	3.90	4.40	4.35	4.65
5 d.	-	-	-	3.60	4.65**	5.50	4.70
4 d.	-	-	-	4.40	4.00	5.00	5.10*
3 d.	4.84**	1.91'**	-	4.90	4.00	4.85**	4.80**
2 d.	2.93	2.69	6.50	4.60	-	4.85	-
1 d.	4.79	1.86'	5.60*	3.70	3.15	4.95	3.90
12 h.	-	2.74	-	-	4.20	4.35	-
4 h.	2.32	1.50	3.20**	-	-	-	3.40
1 h.	-	-	-	-	-	-	-
C.	2.42	1.64	1.72	2.70	2.95	1.30	-
2 h.	-	1.31	1.65	2.50	3.02	-	-
4 h.	4.06	2.47	2.55	2.30	-	1.60	-
8 h.	4.10	0.32	3.50	-	4.50	2.40	-
12 h.	4.58	2.17	4.10	2.80	4.05	1.00	1.50
16 h.	3.27	-	-	-	2.32	1.45	1.15
20 h.	-	1.06	-	2.90	3.00	-	2.45
24 h.	4.66	4.05	4.20'	3.30	3.77'	1.40	1.88'
32 h.	3.69	-	-	-	3.60	0.75'	1.90
40 h.	3.85	3.08	4.18	3.40	-	3.65	2.05
2 d.	3.02'	2.84'	6.02'	3.50'	3.22"	3.70"	6.25
3- 4 d.	1.11	2.77	5.25	3.55'	3.85'	3.28'	5.23'
5- 7 d.	2.55	4.37	4.80	3.70	5.58'	2.80	5.90
10-20 d.	3.93	0.53	6.30	4.30	6.10	5.70	3.70

* and ** See text.

Key to Symbols - see page i, Appendix I.

Total Acid Soluble Phosphate Levels in Pre-partum Milked Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Normal Cows. Number of Calving II. No.B9.	II. No.B14.	IV. No.B29.	V. No.35.	V. No.59.	Milk Fever Cases. Number of Calving V. No.66.	VI. No.31.
37 d.	-	5.10	-	-	-	-	-
34 d.	-	6.80	-	-	-	-	-
31 d.	-	5.30	-	-	-	-	-
26 d.	-	6.95	-	-	-	-	-
18-17 d.	-	5.85	-	6.10	-	-	-
15-14 d.	-	-	-	6.00*	5.80	-	-
13-12 d.	-	-	-	6.00	6.90*	6.63'*	-
11 d.	-	6.10	-	7.25	-	7.90	-
10 d.	5.75	-	-	7.00	-	6.85	-
9 d.	-	-	-	7.50**	5.25	6.75	-
8 d.	6.10*	-	-	6.80	-	6.60	-
7 d.	-	5.00*	-	5.65	-	7.10	-
6 d.	5.50	-	-	5.10	4.90	6.05	4.90
5 d.	-	-	-	4.70	4.90**	7.10	5.10
4 d.	-	-	-	4.80	4.70	6.75	4.90*
3 d.	5.30**	4.63'**	-	5.75	4.40	7.60**	4.60**
2 d.	4.45	4.25	8.60	4.95	-	7.25	-
1 d.	6.10	3.88'	7.80*	4.50	3.65	6.05	3.65
12 h.	-	4.10	-	-	4.20	6.50	-
4 h.	5.75	3.85	4.45**	-	-	-	3.55
1 h.	-	-	-	-	-	-	-
C.	4.65	2.90	3.40	4.05	3.10	2.40	-
2 h.	-	3.75	3.30	4.00	3.20	-	-
4 h.	5.00	4.75	3.65	3.80	-	2.25	-
8 h.	5.25	3.25	5.30	-	4.90	3.15	-
12 h.	6.05	3.85	6.40	4.10	5.20	2.20	1.50
16 h.	5.20	-	-	-	3.15	2.45	1.55
20 h.	-	4.30	-	4.10	3.75	-	3.40
24 h.	6.20	5.20	6.25'	4.75	4.20'	1.70	2.98'
32 h.	5.95	-	-	-	4.30	1.35'	3.30
40 h.	5.05	4.05	5.50	4.85	-	4.90	3.35
2 d.	3.93'	3.75'	8.13'	4.70'	3.85"	4.77"	8.30
3- 4 d.	2.55	4.75	7.40	4.60'	5.20'	4.30'	5.23'
5- 7 d.	4.30	4.90	7.25	4.35	6.95'	4.50	7.45
10-20 d.	5.80	5.15	7.75	5.25	7.25	6.30	4.95

* and ** See text.

Key to symbols - see page i, Appendix I.

Lipid Phosphate Levels in Pre-partum Milked Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Normal Cows. Number of Calving II. No.B9.	II. No.B14.	IV. No.B29.	V. No.35.	V. No.59.	Milk Fever Cases. Number of Calving V. No.66.	VI. No.31.
37 d.	-	3.77	-	-	-	-	-
34 d.	-	3.30	-	-	-	-	-
31 d.	-	3.30	-	-	-	-	-
26 d.	-	3.05	-	-	-	-	-
18-17 d.	-	4.35	-	3.60	-	-	-
15-14 d.	-	-	-	4.30*	4.40	-	-
13-12 d.	-	-	-	3.80	4.40*	5.00*	-
11 d.	-	3.10	-	2.20	-	3.70	-
10 d.	5.95	-	-	3.10	-	4.00	-
9 d.	-	-	-	2.80**	3.80	4.60	-
8 d.	5.80*	-	-	3.10	-	5.40	-
7 d.	-	4.50*	-	3.40	-	5.00	-
6 d.	6.30	-	-	3.50	3.90	4.90	3.20
5 d.	-	-	-	3.70	3.80**	4.60	2.50
4 d.	-	-	-	3.20	3.60	4.50	4.70*
3 d.	6.20**	4.23'**	-	3.10	3.70	2.80**	4.00**
2 d.	5.05	4.05	1.70	3.70	-	3.20	-
1 d.	6.40	4.08'	1.80*	3.10	3.90	3.90	5.60
12 h.	-	4.00	-	-	3.90	2.30	-
4 h.	5.65	4.15	2.00**	-	-	-	2.90
1 h.	-	-	-	-	-	-	-
C.	5.05	3.80	1.10	2.70	3.30	3.90	-
2 h.	-	3.45	1.60	2.70	1.00	-	-
4 h.	4.90	4.15	1.50	2.80	-	3.70	-
8 h.	4.65	3.95	1.50	-	1.10	3.00	-
12 h.	5.25	3.45	1.20	2.80	1.50	3.60	3.10
16 h.	5.00	-	-	-	1.50	3.90	2.90
20 h.	-	4.20	-	3.20	1.50	-	3.00
24 h.	5.30	3.40	1.20'	3.30	1.95'	4.50	2.65'
32 h.	5.65	-	-	-	2.10	5.20'	2.50
40 h.	4.85	4.25	1.40	3.20	-	5.30	1.80
2 d.	5.47'	4.15'	1.25'	3.25'	1.83*	5.70"	2.80
3- 4 d.	5.65	4.55	1.40	4.05	2.45'	5.65	2.50'
5- 7 d.	5.60	5.50	1.20	4.00	2.50'	4.00	2.90
10-20 d.	3.90	4.95	5.70	6.30	2.90	5.20	4.20

* and ** See text.

Key to symbols - see page i, Appendix I.

Total Phosphate Levels in Pre-partum Milked Cows.

Mgms. P./100 ml. Plasma.

Time from Calving.	Normal Cows. Number of Calving II. No.B9.	II. No.B14.	IV. No.B29.	V. No.35.	V. No.59.	Milk Fever Cases. Number of Calving V. No.66.	VI. No.31.
37 d.	-	8.60	-	-	-	-	-
34 d.	-	10.10	-	-	-	-	-
31 d.	-	8.60	-	-	-	-	-
26 d.	-	10.00	-	-	-	-	-
18-17 d.	-	10.20	-	9.00	-	-	-
15-14 d.	-	-	-	9.60*	9.90	-	-
13-12 d.	-	-	-	10.20	10.90*	11.45'*	-
11 d.	-	9.20	-	10.20	-	12.30	-
10 d.	11.70	-	-	9.50	-	10.60	-
9 d.	-	-	-	10.10**	9.70	10.40	-
8 d.	11.90*	-	-	9.60	-	11.20	-
7 d.	-	9.50*	-	8.50	-	11.30	-
6 d.	11.80	-	-	8.40	9.30	10.40	8.50
5 d.	-	-	-	7.70	8.90**	11.20	9.50
4 d.	-	-	-	8.60	8.20	10.80	9.10*
3 d.	11.50**	8.85'**	-	8.80	7.90	11.00**	8.40**
2 d.	10.50	8.30	10.50	9.10	-	10.80	-
1 d.	12.50	7.95'	10.70*	7.80	7.70	10.50	7.20
12 h.	-	8.10	-	-	7.80	10.30	-
4 h.	11.40	8.00	7.00**	-	-	-	6.70
1 h.	-	-	-	-	-	-	-
C.	9.70	6.70	5.50	6.90	6.50	6.70	-
2 h.	-	7.20	5.40	6.50	4.50	-	-
4 h.	9.90	8.70	5.40	6.20	-	6.60	-
8 h.	9.90	7.20	6.70	-	6.30	7.20	-
12 h.	11.30	7.30	8.30	6.60	6.50	6.40	4.50
16 h.	10.20	-	-	-	4.30	6.50	4.70
20 h.	-	8.50	-	6.80	4.00	-	6.30
24 h.	11.50	8.60	8.05'	7.30	6.40'	6.70	12.10'
32 h.	11.60	-	-	-	6.20	7.05'	12.00
40 h.	9.90	8.30	7.20	7.20	-	9.60	11.90
2 d.	9.40'	7.90'	9.15'	7.60'	5.93"	9.97"	10.30
3- 4 d.	8.20	9.30	8.90	8.25'	7.10'	9.40'	9.65'
5- 7 d.	9.90	10.40	9.20	8.30	9.20'	8.50	9.40
10-20 d.	9.70	10.10	13.80	11.20	10.20	11.70	8.80

* and ** See text.

Key to symbols - see page i, Appendix I.

Blood and Milk Phosphates before Calving, in Pre-partum Milked Cows.

Cow No.	Time before Calving.	Plasma Phosphates. Tot.Acid Sol.P.*	Plasma Phosphates. Total P.*	Milk. Yield. Kgms./day.	Milk. Total P. Gms./day.
B 9.	8 d.	6.10	11.90	0.18	0.25
	6 d.	5.50	11.80	0.38	0.63
	3 d.	5.30	11.50	5.90	10.15
	2 d.	4.45	10.50	7.26	11.91
	1 d.	6.10	12.50	9.76	15.03
	4 h.	5.75	11.40	10.67	15.58
B14.	7 d.	5.00	9.50	0.06	0.07
	3 d.	3.90	8.20	2.72	5.01
	3 d.	5.35	9.50	5.45	8.23
	2 d.	4.25	8.30	5.45	7.08
	1 d.	4.15	8.30	9.08	15.53
	1 d.	3.60	7.60	8.17	12.26
	12 h.	4.10	8.10	12.71	18.81
	4 h.	3.85	8.00	12.71	17.80
	C.	2.90	6.70	17.25	22.95
35.	15 d.	6.00	9.60	0.19	0.08
	11 d.	7.25	10.20	1.04	0.73
	10 d.	7.00	9.50	1.26	0.66
	9 d.	7.50	10.10	2.12	1.20
	8 d.	6.80	9.60	3.52	2.15
	7 d.	5.65	8.50	5.34	4.00
	6 d.	5.10	8.40	7.66	9.17
	5 d.	4.70	7.70	8.87	11.92
	4 d.	4.80	8.60	9.96	13.29
	3 d.	5.75	8.80	12.71	16.17
	2 d.	4.95	9.10	12.60	14.95
	1 d.	4.50	7.80	13.85	16.46
	C.	4.05	6.90	13.62	16.78
59.	12 d.	6.90	10.90	0.06	0.02
	9 d.	5.25	9.70	0.30	0.27
	6 d.	4.90	9.30	0.75	1.00
	5 d.	4.90	8.90	3.08	4.34
	4 d.	4.70	8.20	4.20	6.17
	3 d.	4.40	7.90	7.26	10.92
	1 d.	3.65	7.70	10.78	13.95
	12 h.	4.20	7.80	13.96	17.84
	C.	3.10	6.50	9.53	11.36
B29.	1 d.	7.80	10.70	0.16	0.11
	4 h.	4.45	7.00	0.91	1.52
	C.	3.40	5.50	5.45	9.24

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Blood and Milk Phosphates before Calving,
in Pre-partum Milked Cows.

Cow No.	Time from Calving.	Plasma Phosphates.		Milk.	
		Tot.Acid Sol.P.*	Total P.*	Yield. Kgms./day.	Total P. Gms./day.
66.	12 d.	5.40	10.80	0.15	0.09
	11 d.	7.90	12.30	0.09	0.06
	10 d.	6.85	10.60	0.06	0.05
	9 d.	6.75	10.40	0.14	0.13
	8 d.	6.60	11.20	0.12	0.12
	7 d.	7.10	11.30	0.19	0.22
	6 d.	6.05	10.40	0.18	0.23
	5 d.	7.10	11.20	0.24	0.33
	4 d.	6.75	10.80	0.27	0.37
	3 d.	7.60	11.00	0.68	0.92
	2 d.	7.25	10.80	0.91	1.21
	1 d.	6.05	10.50	2.50	3.57
	12 h.	6.50	10.30	6.13	10.25
	C.	2.40	6.70	10.90	17.00
31.	4 d.	4.90	9.10	0.31	0.34
	3 d.	4.60	8.40	0.90	1.24
	1 d.	3.65	7.20	1.79	2.99
	4 h.	3.55	6.70	8.63	14.41

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Blood and Milk Phosphates after Calving, in Pre-partum Milked Cows.

Cow No.	Time after Calving.	Plasma Phosphates. Tot.Acid Sol.P.*	Plasma Phosphates. Total P.*	Milk. Yield. Kgms./day.	Milk. Total P. Gms./day.
B 9.	8 h.	5.25	9.90	13.62	19.48
	16 h.	5.20	10.20	12.71	15.89
	32 h.	5.95	11.60	17.25	20.53
	40 h.	5.05	9.90	13.62	15.25
	2 d.	3.45	9.00	13.17	15.01
	3 d.	2.55	8.20	14.53	17.00
	7 d.	4.30	9.90	12.94	14.88
	14 d.	5.80	9.70	8.63	8.37
B14.	4 h.	4.75	8.90	12.71	15.57
	20 h.	4.30	8.50	18.16	23.06
	32 h.	4.05	8.30	19.52	23.62
	2 d.	3.10	7.40	24.52	27.95
	2 d.	4.40	8.40	19.52	24.21
	3 d.	4.75	9.30	22.25	26.92
	7 d.	4.90	10.40	24.74	27.96
	16 d.	5.15	10.10	28.60	28.89
35.	2 h.	4.00	6.50	20.43	24.90
	16 h.	4.10	6.80	21.34	25.31
	40 h.	4.85	7.20	25.42	27.31
	2 d.	4.60	7.70	25.42	27.41
	5 d.	4.85	8.70	25.03	26.63
59.	24 h.	4.20	6.40	15.66	15.92
	32 h.	4.30	6.20	17.71	18.62
	2 d.	4.25	6.10	15.32	16.01
	3 d.	4.20	6.40	14.53	14.62
	7 d.	5.90	7.80	17.71	16.40
	14 d.	7.25	10.20	21.01	19.06
B29.	8 h.	5.30	6.70	6.36	9.52
	24 h.	5.60	7.00	9.79	12.57
	2 d.	7.60	8.70	11.80	14.06
	3 d.	7.40	8.90	10,90	12.01
	7 d.	7.25	9.20	14.07	15.11
	15 d.	7.75	13.80	13.17	11.45
66.	12 h.	2.20	6.40	7.26	10.21
	24 h.⊥	1.70	6.70	7.72	10.21
	32 h.	3.90	8.90	7.26	9.54
	2 d.	4.60	9.60	11.58	13.12
	3 d.	4.75	9.50	13.62	14.36
	8 d.	4.50	8.50	14.76	16.10
	14 d.	6.30	11.70	17.03	14.83
31.	12 h.⊥	1.50	4.50	2.95	5.19
	2 d.	8.30	10.30	2.04	2.47
	3 d.	7.05	9.30	9.08	9.44
	4 d.	7.50	10.00	9.99	9.89
	6 d.	7.45	9.40	13.17	11.72
	9 d.	5.05	8.40	16.12	16.44

* Mgms. P./100 ml. Plasma.

⊥ Time of Milk Fever.

Key to symbols - see page i, Appendix I.

APPENDIX II.

Table a. Plasma Inorganic Phosphate Levels in Normal Parturient Cows.

Time from Calving.	Number of Calving. I. N.	Mean.*	S.E.	II. N.	Mean.*	S.E.	III. N.	Mean.*	S.E.	IV - VI. N.	Mean.*	S.E.
2 d.	4	5.60	± 0.352	7	6.13	± 0.170	9	5.60	± 0.238	8	5.64	± 0.445
1 d.	5	5.27	± 0.231	6	6.12	± 0.262	5	5.88	± 0.389	6	5.34	± 0.376
12 h.	4	5.50	± 0.237	5	5.71	± 0.286	4	5.49	± 0.277	5	4.72	± 0.256
4 h.	4	5.48	± 0.452	5	4.94	± 0.339	3	4.53	± 0.217	1	4.20	± 0.000
1 h.	4	4.48	± 0.645	5	4.62	± 0.377	6	3.69	± 0.191	2	3.68	± 2.025
C.	6	4.51	± 0.452	7	3.94	± 0.347	8	3.41	± 0.100	6	2.79	± 0.409
2 h.	4	4.93	± 0.199	5	4.46	± 0.453	8	3.43	± 0.130	4	4.13	± 0.628
4 h.	4	6.40	± 0.411	6	5.85	± 0.252	8	4.58	± 0.385	8	3.78	± 0.531
8 h.	2	7.13	± 0.325	6	5.85	± 0.412	6	4.88	± 0.577	6	4.63	± 0.600
12 h.	5	6.86	± 0.585	5	5.93	± 0.272	4	4.69	± 0.824	5	3.84	± 0.363
16 h.	3	5.97	± 0.637	3	6.02	± 0.413	5	4.25	± 0.415	6	4.78	± 0.417
20 h.	3	6.33	± 0.801	2	5.75	± 0.550	4	5.18	± 0.429	3	4.35	± 0.522
24 h.	2	5.40	± 0.750	5	5.92	± 0.334	6	4.13	± 0.255	2	4.50	± 0.500
32 h.	5	4.94	± 0.485	4	5.90	± 0.268	1	3.50	± 0.000	5	4.96	± 0.355
40 h.	2	4.43	± 0.725	2	5.38	± 0.475	5	3.65	± 0.309	2	5.20	± 0.400
2 d.	4	4.81	± 0.707	7	5.28	± 0.246	9	4.76	± 0.375	6	4.48	± 0.189
3- 4 d.	4	4.40	± 0.670	8	5.69	± 0.235	6	5.44	± 0.574	6	5.51	± 0.267
5- 7 d.	4	5.48	± 0.496	4	6.08	± 0.240	4	4.99	± 0.524	4	5.65	± 0.276
10-20 d.	7	5.95	± 0.135	8	5.71	± 0.212	9	6.26	± 0.334	5	5.74	± 0.421

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Table b. Plasma Inorganic Phosphate Levels in Normal Parturient Cows, and Significant Differences.

Time from Calving.	Number of Calving. I & II. N.	Mean.* ± S.E.	III - VI. N.	Mean.* ± S.E.	Sig. %
2 d.	11	5.94 ± 0.176	17	5.62 ± 0.236	N.S.
1 d.	11	5.73 ± 0.215	11	5.59 ± 0.270	N.S.
12 h.	9	5.62 ± 0.183	9	5.06 ± 0.225	N.S.
4 h.	9	5.18 ± 0.273	4	4.45 ± 0.175	N.S.
1 h.	9	4.56 ± 0.347	8	3.69 ± 0.408	N.S.
C.	13	4.20 ± 0.280	14	3.15 ± 0.195	1.00
2 h.	9	4.67 ± 0.265	12	3.66 ± 0.230	0.10
4 h.	10	6.07 ± 0.227	16	4.18 ± 0.333	0.10
8 h.	8	6.17 ± 0.372	12	4.75 ± 0.400	5.00
12 h.	10	6.40 ± 0.341	9	4.22 ± 0.414	0.10
16 h.	6	5.99 ± 0.339	11	4.54 ± 0.293	1.00
20 h.	5	6.10 ± 0.493	7	4.82 ± 0.345	5.00
24 h.	7	5.77 ± 0.299	8	4.23 ± 0.298	1.00
32 h.	9	5.37 ± 0.361	6	4.72 ± 0.378	N.S.
40 h.	4	4.90 ± 0.448	7	4.09 ± 0.367	N.S.
2 d.	11	5.11 ± 0.296	15	4.65 ± 0.289	N.S.
3- 4 d.	12	5.26 ± 0.313	12	5.48 ± 0.306	N.S.
5- 7 d.	8	5.78 ± 0.279	8	5.32 ± 0.301	N.S.
10-20 d.	15	5.82 ± 0.129	14	6.08 ± 0.262	N.S.

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Table c. Plasma Total Acid Soluble Phosphate Levels in Normal Parturient Cows, and Significant Differences.

Time from Calving.	Number of Calving. I & II. N.	Mean.* ± S.E.	III - VI. N.	Mean.* ± S.E.	Sig. %
2 d.	6	7.78 ± 0.241	8	6.81 ± 0.609	N.S.
1 d.	7	7.00 ± 0.202	7	7.09 ± 0.568	N.S.
12 h.	4	6.95 ± 0.121	5	6.29 ± 0.353	N.S.
4 h.	5	6.04 ± 0.391	2	5.50 ± 0.200	N.S.
1 h.	7	5.56 ± 0.335	3	4.72 ± 1.566	N.S.
C.	8	5.66 ± 0.584	7	3.80 ± 0.314	5.00
2 h.	6	6.20 ± 0.647	6	4.66 ± 0.471	N.S.
4 h.	8	7.24 ± 0.265	8	5.21 ± 0.410	0.10
8 h.	6	7.55 ± 0.376	6	6.08 ± 0.545	5.30
12 h.	6	7.33 ± 0.414	6	5.16 ± 0.482	1.00
16 h.	5	6.59 ± 0.679	6	6.37 ± 0.753	N.S.
20 h.	4	7.74 ± 0.130	4	5.88 ± 0.391	1.00
24 h.	4	6.96 ± 0.599	1	5.35 ± 0.000	N.S.
32 h.	5	6.74 ± 0.477	6	6.25 ± 0.429	N.S.
40 h.	4	6.19 ± 0.231	3	5.97 ± 0.130	N.S.
2 d.	8	6.07 ± 0.368	8	5.50 ± 0.687	N.S.
3- 4 d.	6	6.33 ± 0.496	7	6.61 ± 0.499	N.S.
5- 7 d.	6	6.93 ± 0.245	5	6.56 ± 0.350	N.S.
10-20 d.	8	6.71 ± 0.199	6	7.21 ± 0.553	N.S.

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Table d. Plasma Lipid Phosphate Levels in Normal Parturient Cows.

Time from Calving.	Number of Calving.					
	I & II.			III - VI.		
	N.	Mean.* ±	S.E.	N.	Mean.* ±	S.E.
2 d.	6	4.68 ±	0.866	8	3.59 ±	0.534
1 d.	7	4.33 ±	0.900	6	3.91 ±	0.737
12 h.	4	4.49 ±	0.787	5	3.62 ±	1.007
4 h.	5	3.50 ±	0.698	1	6.20 ±	0.000
1 h.	7	3.79 ±	0.922	3	3.70 ±	1.501
C.	9	3.99 ±	0.470	6	3.12 ±	0.774
2 h.	6	3.67 ±	0.791	6	3.13 ±	0.535
4 h.	8	3.99 ±	0.742	8	2.89 ±	0.485
8 h.	6	3.97 ±	0.463	6	2.93 ±	0.527
12 h.	7	3.49 ±	0.614	6	3.08 ±	0.629
16 h.	5	4.53 ±	0.885	5	3.56 ±	0.828
20 h.	4	4.10 ±	0.795	4	3.40 ±	1.045
24 h.	4	3.25 ±	1.095	1	3.70 ±	0.000
32 h.	5	4.58 ±	0.853	6	2.77 ±	0.973
40 h.	4	3.75 ±	0.851	3	3.70 ±	1.588
2 d.	7	3.77 ±	0.657	8	3.19 ±	0.551
3- 4 d.	6	4.67 ±	0.723	7	3.79 ±	0.618
5- 7 d.	6	4.78 ±	0.714	5	4.44 ±	0.813
10-20 d.	8	6.08 ±	0.577	6	4.90 ±	0.635

There are no significant differences between the first and second calving and the third to sixth calving cows.

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Table e. Plasma Total Phosphate Levels in Normal Parturient Cows, and Significant Differences.

Time from Calving.	Number of Calving. I & II. N.	Mean.*	S.E.	III - VI. N.	Mean.*	S.E.	Sig. %
2 d.	6	12.02	± 0.756	8	10.35	± 0.680	N.S.
1 d.	7	10.98	± 0.727	7	10.66	± 0.752	N.S.
12 h.	4	11.09	± 0.605	5	10.10	± 0.883	N.S.
4 h.	5	9.50	± 0.966	2	10.15	± 1.950	N.S.
1 h.	7	8.51	± 0.678	3	8.53	± 1.934	N.S.
C.	8	9.00	± 0.872	7	6.80	± 0.615	7.00
2 h.	6	10.18	± 0.770	6	7.72	± 0.710	5.00
4 h.	8	10.29	± 0.445	8	8.10	± 0.675	5.00
8 h.	6	11.27	± 0.822	6	8.90	± 0.584	5.00
12 h.	6	11.42	± 1.268	6	8.30	± 0.694	6.00
16 h.	5	11.80	± 0.712	6	9.20	± 0.584	2.10
20 h.	3	10.83	± 1.692	4	9.53	± 0.818	N.S.
24 h.	4	10.13	± 0.894	1	8.10	± 0.000	N.S.
32 h.	5	11.08	± 1.089	6	9.35	± 0.623	N.S.
40 h.	4	10.03	± 0.914	3	9.63	± 1.186	N.S.
2 d.	8	9.95	± 0.753	8	8.98	± 0.447	N.S.
3- 4 d.	7	10.77	± 0.686	7	9.69	± 0.511	N.S.
5- 7 d.	6	11.65	± 0.565	5	10.99	± 0.616	N.S.
10-20 d.	8	12.49	± 0.470	6	12.57	± 0.550	N.S.

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

Table f. Plasma Phosphate Levels after Calving in Pre-partum Milked Cows.*

Time after Calving.	Cows at 2nd Calving.						Cows at 3rd - 6th Calving.					
	No. of Cows.	Inorg.P. Mean.	S.E.	T.Ac.Sol.P. Mean.	S.E.	Total P. Mean.	S.E.	No. of Cows.	Inorg.P. Mean.	S.E.	T.Ac.Sol.P. Mean.	S.E.	Total P. Mean.	S.E.
Calving.	2	2.03	0.390	3.78	0.876	8.20	1.500	3	2.46	0.375	3.52	0.280	6.30	0.416
2 h.	1	1.31	0.000	3.75	0.000	7.20	0.000	3	2.39	0.399	3.50	0.252	5.47	0.578
4 h.	2	3.27	0.795	4.88	0.125	9.30	0.600	2	2.43	0.125	3.73	0.748	5.80	0.400
8 h.	2	2.21	1.890	4.25	1.000	8.55	1.350	2	4.00	0.500	5.10	0.200	6.50	0.200
12 h.	2	3.38	1.205	4.95	1.100	9.30	2.000	3	3.65	0.425	5.23	0.664	7.13	0.584
16 h.	1	3.27	0.000	5.20	0.000	10.20	0.000	1	2.32	0.000	3.15	0.000	4.30	0.000
20 h.	1	1.06	0.000	4.30	0.000	8.50	0.000	2	2.95	0.016	3.93	0.175	5.40	1.400
24 h.	2	4.36	0.305	5.70	0.500	10.05	1.450	3	3.76	0.260	5.07	0.613	7.25	0.477
32 h.	1	3.69	0.000	5.95	0.000	11.60	0.000	1	3.60	0.000	4.30	0.000	6.20	0.000
40 h.	2	3.47	0.385	4.55	0.500	9.10	0.800	2	3.79	0.390	5.18	0.325	7.20	0.000
2 d.	2	2.93	0.090	3.84	0.285	8.65	0.750	3	4.25	0.890	5.56	1.308	7.56	0.930
3- 4 d.	2	1.94	0.830	3.65	1.100	8.75	0.550	3	4.22	0.524	5.73	0.851	8.08	0.526
5- 7 d.	2	3.46	0.910	4.60	0.300	10.15	0.250	3	4.69	0.362	6.18	1.128	8.90	0.300
10-20 d.	2	2.23	1.700	5.48	0.325	9.90	0.200	3	5.57	0.636	6.75	0.764	11.73	1.073

* Mgms. P./100 ml. Plasma.

Table g. Plasma Phosphate Changes in a Mastectomised Cow.*

Time from Calving.	Serum Calcium.	Plasma				Ratio Calcium / Total P.
		Inorg. P.	Tot.Acid Sol.P.	Lipid P.	Total P.	
2 d.	11.70	4.54	4.85	4.25	9.10	1.28
1 d.	11.00	3.91	5.05	4.05	9.10	1.21
12 h.	10.60	3.74	4.45	4.25	8.70	1.22
1 h.	10.40	2.24	2.35	5.05	7.40	1.41
C.	10.30'	2.84'	3.15'	4.25'	7.40'	1.39'
2 h.	10.45	3.38	3.65	3.85	7.40	1.42
4 h.	10.60	3.80	4.15	3.75	7.90	1.34
8 h.	10.90	4.71	5.10	3.60	8.70	1.25
12 h.	10.70	5.16	5.70	3.60	9.30	1.15
16 h.	10.80	5.12	5.85	3.45	9.30	1.16
20 h.	11.15	5.36	5.85	3.55	9.40	1.18
24 h.	10.90'	5.70'	6.28'	3.53'	9.80'	1.11'
32 h.	10.70	5.92	6.50	3.40	9.90	1.08
40 h.	10.30	5.59	6.00	3.40	9.40	1.09
2 d.	9.85	6.09	6.55	3.45	10.00	0.99
3- 4 d.	10.20'	6.02'	6.33'	4.37'	10.70'	0.95'
5- 7 d.	10.28'	6.18'	6.53'	4.63'	11.15'	0.92'
10-20 d.	9.80	5.78	6.20	4.00	10.20	0.96

* Mgms. P./100 ml. Plasma.

Key to symbols - see page i, Appendix I.

APPENDIX III.

Observations on the Accuracy of Organic Phosphate Estimations.

Tests of accuracy were made by adding known amounts of standard phosphate solutions to the test material and calculating the percentage recoveries. Results were as follows:-

Total Acid Soluble Phosphate.*

Specimen.	Sample.	Sample P. 2 mgm./100 ml.	Recovery.	Sample P. 5 mgm./100 ml.	Recovery.
Cow Plasma 1.	5.90) 5.95) 6.06 6.20) 6.20)	7.90) 8.15) 8.05 8.10)	99.5%	11.30) 10.90) 11.00 10.80)	99.8%
Cow Plasma 2.	4.10) 4.10) 4.11 4.05) 4.20)	-) 6.15) 6.00 5.85)	94.5%	8.90) 9.00) 8.97 9.00)	97.2%
Sheep Plasma 1.	4.20) 3.90) 4.10 4.10) 4.20)	6.10) 6.10) 6.10 6.10)	100%	8.80) 8.80) 8.77 8.70)	93.4%

Total Phosphate.*

Specimen.	Sample.	Sample P. 4 mgm./100 ml.	Recovery.	Sample P. 10 mgm./100 ml.	Recovery.
Cow Plasma 1.	12.30) 12.70) 12.62 12.60) 12.90)	15.80) 16.20) 16.16 16.50)	88.5%	21.90) 22.10) 22.00 -)	93.4%
Cow Plasma 2.	12.00) 11.80) 11.80 11.80) 11.60)	15.80) 15.40) 15.70 15.90)	97.5%	-) 21.60) 21.80 22.00)	100%

* Mgms. P./100 ml. Plasma.

The added phosphate which was lost in carrying out the estimations was 1.28 ± 0.411 micrograms P.